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OFT-1 MARGIN ASSESSMENT



National Aeronautics and Space Administration
LYNDON B. JOHNSON SPACE CENTER

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OFT-1 MARGIN ASSESSMENT

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1.0 SUMMARY

This paper documents the results of an analysis conducted to determine space shuttle vehicle (SSV) subsystem margins for the reference flight profile (reference 1) for the first orbital flight test (OFT-1). The objective of this assessment was to determine the "benignness" of the candidate OFT-1 launch trajectory in the presence of winds, environment and system dispersions, and aerodynamic uncertainties. In particular, this analysis attempted to answer the following question. "Can the SSV fly the OFT-1 ascent safely (i.e., with adequate subsystems margins) in the presence of dispersions, including aerodynamic variations?"

In general, the results of this analysis show increased margins for the OFT-1 indicators when compared to Mission 3A results. The inclusion of element and wing aerodynamic variations on OFT-1, in combination with winds and systems dispersions, resulted in the forward Z (FT01) attach load indicator exceeding specified "limits". The inboard and outboard elevon hinge moment margins (9 percent and 3 percent, respectively) on OFT-1 reflect values consistent with the load relief requirements dictated by elevon hinge moment variations. All other structural load indicators for OFT-1 had margins in excess of 10 percent.

The SSV first stage stagnation heating indicators for OFT-1 were about 45 percent less than for Mission 3A. The hydraulic systems demands for both missions were essentially the same.

The results of this analysis also show OFT-1 performance requirements from the consideration of winds and dispersions to be approximately 3,300 lbs greater than Mission 3A.

2.0 INTRODUCTION

The orbital flight test (OFT) phase of the Space Shuttle Program currently consists of six orbital flights beginning in March 1979. The primary purpose of the OFT Program is to demonstrate and verify SSV systems and flight capabilities by satisfying various flight test requirements. As a result of the uniqueness of the SSV system and the various unknowns associated with the ascent environment, subsystem requirements have been established to insure as "benign" an ascent as possible for OFT-1.

The purpose of this study is to identify the minimum margin on each subsystem which results from flying the OFT-1 ascent in the design environment. Data are given which compare several vehicle and trajectory parameters for OFT-1 with the corresponding Mission 3A results. The impact of winds and dispersions on OFT-1 and Mission 3A structural load indicator margins is included in this analysis. Also, included in this assessment was the impact of wind criteria and maximum nominal dynamic pressure on OFT-1 margins (see Appendices A and B).

3.0 METHOD OF ANALYSIS

All trajectories for this analysis were computed using a 6 degree-of-freedom trajectory program integrating the equations of motion of a rigid body moving over a rotating oblate spheroid planet under the influence of thrust, gravity, and aerodynamic forces. For the purposes of this analysis, no system failures of any kind were considered in the determination of vehicle performance or subsystem margins. The following items were used as the measure of OFT-1 "benignness":

1. SSV trajectory and load indicators

- a. Performance (injected weight at nominal main engine cutoff)
- b. SRB staging conditions
- c. Maximum first stage heating
- d. First stage hydraulic flow requirements
- e. Maximum dynamic pressure
- f. Liquid oxygen (LOX) tank aft bulkhead load
- g. Elevon hinge moments
- h. Wing structural load indicators
- i. Orbiter/ET attach load indicators
- j. SRB/ET attach load indicators

2. Comparison of the above indicators on OFT-1 with baseline reference Mission 3A.

The assumptions and ground rules for this margin assessment are presented in figure 1. The synthetic vector wind profiles combined the 95 percentile steady state envelope with 99 percentile shear build-up and gust (including the 0.85 factor) at Mach number = 0.9, 1.05, 1.25, 1.55, and 2.0. Programmed elevon schedule 6 (given in figure 2) was used on both Missions 3A and OFT-1 with active elevon load relief. Figure 3 provides a comparison of the required space shuttle main engine (SSME) thrust profiles for Mission 3A and OFT-1, respectively. Figure 4 gives the structural load indicator limits used in this analysis to compute margins. These limits are "flag" values which include the impact of winds and dispersions but no system failures or flexible body effects. The Orbiter/ET and SRB/ET attach load indicators are defined in figure 5. All aerodynamic uncertainties used in this analysis include tolerances on Mission 3A and variations on OFT-1.

For the purposes of this analysis, minimum SSV load indicator and vehicle subsystem margins were determined by root sum squaring (RSS) the delta resulting from each system and environment dispersion and subtracting the result from the mean wind nominal value (see figure 6). It should be noted that this approach is somewhat different from the criteria employed in the integrated vehicle baseline characterization (IVBC #2) analysis cycle. This latter approach involved combining "A", "A1", and "B" Q_α/Q_β envelopes. Since resources were not available to generate this data base for both Missions 3A and OFT-1 with consistent groundrules, the technique summarized in figure 6 was employed for combining the effects of individual dispersions. Furthermore, examination of the selected approach results in a "squatcheloid" within 200 psf-degrees of the IVBC #2 approach.

4.0 DISCUSSION OF RESULTS

4.1 NOMINAL ASCENT

The nominal OFT-1 ascent in the presence of the Eastern Test Range (ETR) April mean wind resulted in values of trajectory parameters, first stage heating, hydraulic flow profiles, and structural load indicators which can be considered to be the "most probable." Figures 7 to 21 present time (or Mach number) histories of several parameters considered significant to making a margin assessment. Also, included for comparison purposes are the indicators for the nominal Mission 3A trajectory profile in the presence of the WTR December mean wind. The structural load indicators are presented (figures 22 - 40) over the Mach number range (0.6 to 2.2) for which IVBC-2 element aerodynamic data was available (see reference 5).

Figure 41 summarizes the first stage heating, hydraulic flow requirements, and maximum LOX bulkhead load for the nominal OFT-1 and Mission 3A trajectories. As can be seen, appreciable reduction in the first stage heat load and maximum heat rate resulted from the more lofted OFT-1 trajectory. As indicated, there is essentially no difference in the hydraulic requirements for the nominal OFT-1 and Mission 3A first stage ascent (note that the maximum flow required is significantly less than the 63 gallons per minute (gpm) capability of each hydraulic system when operating at 100 percent auxiliary power unit (APU) speed). However, the LOX bulkhead load indicator for OFT-1 had a higher loading (13.8 percent margin) than Mission 3A (17.4 percent margin) as a result of deeper SSME throttling and subsequent larger amounts of oxidizer remaining in the first stage maximum acceleration (g) region on OFT-1.

Figure 42 presents the nominal (mean wind) solid rocket booster (SRB) staging conditions for reference Missions 3A and OFT-1. The high degree of lofting typical of OFT-1 trajectory profiles designed to maintain a maximum dynamic pressure of 550 psf is evident in the values of h , V , γ , and Q . OFT-1

body rates, α and β are similar to the Mission 3A values and represent considerable margin in achieving the allowable SRB staging initial conditions (reference 15) under nominal conditions.

Figure 43 summarizes the minimum margins observed for each of the structural load indicators throughout the mean wind nominal Missions 3A and OFT-1 first stage trajectories. In general, the structural load indicators for OFT-1 do not reflect the increase in margin over Mission 3A that the 100 psf reduction in maximum dynamic pressure might imply. This is primarily due to the fact that the OFT-1 profile was constrained (see reference 1) to an elevon schedule and $Q\alpha$ profile designed for Mission 3A. The most significant margin difference between OFT-1 and Mission 3A is seen in the forward X SRB/ET attach load indicators (FTB5 and FTB6) and the aft X Orbiter/ET attach load indicators (FT07 and FT08). The difference in margin on these two sets of attach indicators can be attributed to the difference in SSME throttle requirements (see figure 3) on these two missions. The deeper throttle required by OFT-1 to obtain 550 psf maximum dynamic pressure results in an increase in the axial loading of the SRB's relative to the external tank (ET) (see figure 37) and of the Orbiter relative to the ET (see figures 33 - 34). Figure 44 provides a comparison of the flutter margin available on the nominal Mission 3A (21 percent) and OFT-1 (30 percent) ascent trajectories.

4.2 INFLIGHT WINDS

Figure 45 gives the squatcheloid at $M = 1.05$ which resulted from flying the 3A and OFT-1 profiles in the presence of 95 percentile vector winds with shear buildup and gust. As would be expected from the reduced maximum dynamic pressure of the nominal OFT-1 trajectory, the $Q\alpha/Q\beta$ span for OFT-1 is reduced by approximately 600 psf-degrees. The sensitivity of each SSV structural load indicator at $M = 1.05$ to variations in wind direction (squatcheloid angle, ψ , defined in figure 45) is given in figures 46 through 74 for both Missions 3A and OFT-1). From this data, the worst wind directions for each load indicator were identified for the purpose of determining the minimum load indicator margin that results from winds throughout the first stage Mach number range. By simulating the OFT-1 and Mission 3A profiles in the presence of these selected wind directions with shear buildup and gust for each of several Mach numbers in the maximum dynamic pressure region, it is possible to assess the sensitivity of the load indicators to both wind direction and shear/gust Mach number.

Each of the squatcheloids given in figure 75 indicate a reduction in the $Q\alpha/Q\beta$ span of from 300 to 600 psf-degrees for the OFT-1 wind response as compared to the Mission 3A wind response. The sensitivity of the OFT-1 and Mission 3A structural load indicators to the wind gust Mach number and to variations in wind direction is given in figures 76 - 104. The impact of winds on structural load indicator margins is given in figures 105-121 for both OFT-1 and Mission 3A. Figures 122 and 123 summarize the minimum

structural load indicator margins which result considering 95 percentile winds from any direction with a shear buildup and gust occurring between $M = 0.90$ and $M = 2.0$. From these figures, OFT-1 reflects an overall increase in structural load indicator margin relative to Mission 3A except for the SSME thrust dependent Orbiter/ET and SRB/ET attach load indicators (FT07, FT08, FTB5, and FTB6). While the margins for these indicators were still quite significant, the deeper SSME throttle requirements on OFT-1 caused a reduction in indicator margin over the Mission 3A margins. In general, it can be concluded that in the presence of 95 percentile winds (all other parameters nominal) minimum indicator margins for OFT-1 and 3A result on the wing/elevon structural load indicators with most indicator margins exceeding 30 percent. It is important to note that these results indicate that in-flight winds may require outboard elevon load relief.

The variation of maximum dynamic pressure with squatcheloid angle and shear/gust Mach number is presented in figures 124 and 125 for OFT-1 and Mission 3A. The impact of the worst case head wind on flutter margin for Mission 3A and OFT-1 is shown in figure 126. Figure 127 summarizes the impact of this head wind on SSV maximum dynamic pressure and flutter margin for both Missions 3A and OFT-1.

Figure 128 summarizes the impact of winds on the parameters of interest in the SSV first stage maximum acceleration (g) flight regime. The LOX bulkhead load indicator is insensitive to variations in wind direction or to variations in the wind gust altitude. The maximum reduction in LOX bulkhead indicator margin due to winds was about 1.5 percent on both OFT-1 and Mission 3A. The sensitivity of maximum first stage stagnation heat rate to changes in wind direction is shown in figures 129 and 130 for Mission 3A and OFT-1. The maximum first stage heat rate variation was about ± 25 percent with 95 percentile winds for both Missions 3A and OFT-1.

The impact of 95 percentile vector winds on SRB staging conditions is shown in figure 131 for both OFT-1 and Mission 3A. The only area that may be of some concern as a result of winds would seem to be the degree of lofting that results on OFT-1 from the predominant ETR tailwinds. This significant difference in the OFT-1 staging state vector from baseline reference Mission 3A may require an assessment of SSV venting and the SRB entry environment to alleviate any concerns in these areas (no problems anticipated).

The SSV hydraulic flow requirements were found to be insensitive to the 95 percentile inflight winds on both Mission 3A and OFT-1.

Figures 132 and 133 give the variation of vehicle injected weight with squatcheloid angle and shear/gust Mach number for 95 percentile winds. For Mission 3A, a maximum reduction in SSV injected weight of 1400 pounds results from a tailwind with shear buildup and gust occurring at $M = 0.90$. Similarly for OFT-1, a maximum reduction in injected weight of about 3,600 pounds resulted from tailwinds and left crosswinds. This additional sensitivity of OFT-1 vehicle performance to crosswinds can be attributed to the large amount of yaw steering required to constrain the abort-once-around (AOA)

entry crossrange to 500 nautical miles or less. It should also be noted that this reduction in SSV injected weight on OFT-1 is significantly larger than the amount of flight performance reserves (FPR) which is dedicated to account for wind variations on the baseline reference missions.

4.3 SYSTEM DISPERSIONS

4.3.1 MATED VEHICLE

For the purposes of this analysis, each dispersion (aerodynamic and SSV system) as presented in the groundrules in figure 1 was simulated individually in the presence of the nominal mean wind. Figures 134 and 135 identify for OFT-1 and Mission 3A respectively, the dispersions which produced the largest variation of each structural load indicator from its nominal value between $M = 1.05$ and $M = 1.25$. The impacts of each dispersion on SSV trajectory parameters and load indicators were combined (delta's root sum squared, RSS'd) to obtain the overall variation of indicator margin due to nonwind dispersions. Figure 136 gives the variation of squatcheloid radius

$$\left(\Delta R, \sqrt{(\Delta Q_\alpha)^2 + (\Delta Q_\beta)^2} \right)$$

which results from the RSS of the dispersions used in this analysis. While the results for both OFT-1 and Mission 3A indicate a maximum Q_α/Q_β span increase of about 1,500 psf-degrees, it must be recalled that mated vehicle aerodynamic variations were included in the OFT-1 dispersions and tolerances in Mission 3A.

Referring to figures 137 - 153 it is possible to determine the impact of the dispersions (RSS'd) on the structural load indicator margins for Mission 3A and OFT-1. Figures 154 and 155 summarize the minimum margins observed throughout the maximum dynamic pressure region as a result of dispersions for OFT-1 and Mission 3A. By combining the worst case wind (as defined by the scope of this analysis) for each load indicator (see figures 122 and 123 with the RSS of the previously discussed dispersions, it is possible to approximate a minimum expected margin for each structural load indicator for Mission 3A and OFT-1. These results are summarized in figures 156 and 157 and clearly show the sensitivity of the various indicators to winds and dispersions. All indicators (on both Mission 3A and OFT-1) have a least 15 percent margin except for wing shear and the outboard elevon hinge moment. A worst case combination of winds and dispersions reduced the wing shear indicator margin to less than the 20 percent margin identified as desirable for OFT-1 and required outboard elevon hinge moment load relief in the $M = 1.1$ to $M = 1.3$ regime. Some OFT-1 attach load indicators have less margin than corresponding 3A indicators as a result of the deeper SSME throttle requirements on OFT-1 and the use of aerodynamic variations on OFT-1.

The impact of the RSS of the dispersions considered on the LOX bulkhead load indicator and first stage heating is given in figure 158. The RSS of subsystem and aerodynamic dispersions (hot SRB being the major contributor) accounted for about a 5 percent reduction in LOX bulkhead load indicator margin. By combining these dispersions with the worst case winds, an overall margin of 11 percent and 8 percent results for Mission 3A and OFT-1 respectively. As shown, the RSS of the dispersions resulted in about a ± 20 percent variation in the maximum first stage convective heat rate on both OFT-1 and Mission 3A. The maximum variation in first stage heat load was about ± 15 percent for both OFT-1 and Mission 3A. By combining the worst headwind with the RSS of the dispersions, it is possible to determine that the maximum expected heat rate for OFT-1 is 45.6 percent lower than for Mission 3A. Similarly, the maximum expected heat load is 43.6 percent lower. As seen in figure 158, the maximum dynamic pressure variation due to dispersions on OFT-1 is about 15 percent larger than for Mission 3A. The combined impact of worst case dispersions with worst case wind direction (95 percentile headwind) on flutter margin is presented in figure 159 for Missions 3A and OFT-1. As shown, the minimum expected flutter margin for Mission 3A would be 7 percent, while for OFT-1 that margin would be 20 percent.

For the purposes of this analysis, SRB staging conditions were assessed with the same dispersions considered in the maximum dynamic pressure flight regime with the exception that SRB web action time dispersion was replaced with SRB thrust mismatch. Figure 160 gives the SRB staging conditions which result from the worst case SRB mismatch for Missions 3A and OFT-1. The impact of the RSS of all dispersions on staging conditions is summarized in figure 161. As indicated by these results, the baseline flight control system (FCS 8) would not require a separation inhibit to achieve acceptable SRB staging initial conditions.

Except for SRB thrust mismatch, the dispersions considered in this analysis had negligible impact on the SSV hydraulic system demands. The hydraulic flow demands produced by the worst case mismatch dispersions are given in figures 162 and 163 for OFT-1 and Mission 3A. The flow required (approximately 40 gpm pre-staging and 50 gpm post-staging) by these dispersions is well within the capability of the SSV hydraulic system.

The effect of the RSS of the dispersions on SSV injected weight is given in figure 164 for OFT-1 and Mission 3A. As shown, the maximum required propellant for OFT-1 exceeds the 5,200 lbs currently allotted as flight performance reserve. The significantly larger variation in performance on OFT-1 indicates a need for an FPR assessment specifically for OFT-1 as the use of 3A reserves will not be adequate.

4.3.2 ELEMENT AERODYNAMICS

To this point, the discussion in this section has dealt with the overall impact on vehicle and trajectory parameters of an RSS combination of

subsystem dispersions. In addition to these dispersions, this analysis included an assessment of element aerodynamic coefficient tolerances (Mission 3A) and variations (OFT-1). Each element dispersion was considered individually with their collective impact identified by root sum squaring each tolerance or variation delta.

When the appropriate elevon hinge moment uncertainties were considered in trajectory simulations, outboard elevon load relief was required with positive outboard elevon hinge moment tolerances (3A) and variations (OFT-1). Similarly, the only requirement for inboard elevon load relief resulted from negative inboard elevon hinge moment variations on OFT-1. Figures 165 - 168 present the elevon deflections and hinge moments which resulted from flying the nominal Mission 3A and OFT-1 trajectory profiles with hinge moment tolerances and variations, respectively. As seen from these results, approximately 3° of outboard elevon deflection for load relief was required with Mission 3A tolerances and OFT-1 variations. While 3 to 8 degrees of inboard elevon deflection for load relief was required on OFT-1, no load relief was necessary on Mission 3A.

Figures 169 - 185 give the impact of element aerodynamic tolerances (Mission 3A) and variations (OFT-1) on the SSV structural load indicator margins. Figures 186 and 187 summarize the minimum margins which result from the consideration of element aerodynamic dispersions for Missions 3A and OFT-1, respectively. As shown, the inboard and outboard elevon hinge moments and FT01 are the only structural load indicators which have margins reduced to below 20 percent as a result of element aerodynamic tolerances (3A) or variations (OFT-1). It should be pointed out that element aerodynamic tolerances and variations were found to have negligible impact on SSV maximum dynamic pressure, heating, SRB staging conditions, hydraulic requirements, or performance.

5.0 CONCLUSIONS

5.1 STRUCTURAL LOAD INDICATORS

Figures 190 - 206 give the minimum margin as a function of Mach number which results from root sum squaring the mean wind value of each structural load indicator with the resultant delta from inflight winds, system dispersions, and element aerodynamic dispersions. Minimum indicator margins for the maximum dynamic pressure flight regime (3A and OFT-1) are summarized in figures 188 and 189.

The forward Z (FT01) Orbiter/ET attach load indicator (figure 194) was the only attach load indicator for either OFT-1 or Mission 3A which showed sufficient sensitivity to element aerodynamic uncertainties to cause concern. The minimum margin for FT01 on Mission 3A was 8 percent and resulted from the inclusion of element aerodynamic tolerances with the winds and system dispersions effects. On OFT-1 a -2 percent margin on FT01

resulted from the inclusion of element aerodynamic variations with the wind and system dispersions effects. For both OFT-1 and Mission 3A, the minimum margin on all other attach load indicators exceeded 15 percent. In general, for OFT-1 and Mission 3A, the wing/elevon structural load indicators had less than 20 percent minimum margins. While inflight winds were the primary cause of reduced margins on the wing/elevon structural load indicators, none of the limits used in this analysis were exceeded on either Missions 3A or OFT-1 when system dispersions and element uncertainties were also considered. The wing bending and shear structural load indicators on OFT-1 had approximately 10 percent more margin than the corresponding Mission 3A results.

For both OFT-1 and Mission 3A, the LOX bulkhead load indicator was found to be insensitive to winds or dispersions. Primarily as a result of the SRB web action time dispersion, a maximum decrease in indicator margin of only 5 percent from nominal was observed on both Missions 3A and OFT-1. While a minimum margin of 7 percent resulted on Mission 3A, the increased SSME throttle requirements of OFT-1 resulted in a minimum LOX bulkhead load indicator margin of about 4.5 percent.

While elevon hinge moment tolerances (Mission 3A) and variations (OFT-1) required from 3 to 8 degrees of elevon deflection for load relief, additional load relief would be required to increase elevon hinge moment margins. Conceivably, by combining winds and other subsystem dispersions with the hinge moment tolerances or variations, elevon deflections in excess of the 3 to 8 degrees discussed above could be required for load relief.

5.2 MAXIMUM DYNAMIC PRESSURE

A maximum dynamic pressure increase of about 180 psf on Mission 3A and 150 psf on OFT-1 results from a worst case combination of 95 percentile headwinds and dispersions. The 830 psf maximum dynamic pressure on Mission 3A reflects about 7 percent flutter margin while the 700 psf maximum dynamic pressure from OFT-1 simulations reflects a minimum expected flutter margin of about 20 percent. It must be noted that these margins are above operational flutter margin.

5.3 FIRST STAGE HEATING

A worst case combination of dispersions and winds (95 percentile head-2 wind) resulted in a maximum first stage stagnation heat rate of 4.87 Btu/ft²/sec on Mission 3A and about 2.68 Btu/ft²/sec on OFT-1 (maximum heat rate on 3A composite heating trajectory is 4.81 Btu/ft²/sec). These worst case rates reflect maximum first stage heat loads of about 173 Btu/ft² and 94 Btu/ft² on Missions 3A and OFT-1, respectively. These results represent about a 45 percent reduction in first stage stagnation heating indicator for OFT-1 over Mission 3A. While these heating indicators show significant variation due to winds (figure 128) and dispersions (figure 158), the indicator model

used in this analysis only reflects sensitivity to vehicle relative velocity and atmospheric density. As such, α and β effects on vehicle heating are not accounted for in these results.

5.4 HYDRAULICS

SRB thrust mismatch was the only environment or system dispersion which was found to significantly affect SSV hydraulic flow demands in the first stage. On both OFT-1 and Mission 3A this dispersion required about 70 percent of the hydraulic system flow capability just prior to SRB separation. For all other environment and system dispersions, the vertical rise and tilt flight regime has the highest hydraulic flow requirements, approximately 15 gpm (about 25 percent of the capability).

5.5 SRB SEPARATION

OFT-1 and Mission 3A launch trajectory simulations using baseline FCS 8 and a worst case combination of winds and dispersions (including SRB thrust mismatch) resulted in SRB staging conditions within the range of acceptable SRB separation initial conditions identified in reference 15 without the need for a separation delay.

5.6 INJECTED WEIGHT

The worst case combination of winds and dispersions resulted in a maximum SSV injected weight reduction of 5,200 lbs on Mission 3A and 8,550 lbs on OFT-1. This reduction in performance exceeds the 5,200 lbs which is currently allotted for FPR on OFT-1. Also, the large performance variation noted on OFT-1 due to winds (+1,500 lbs to -3,600 lbs, figure 132) indicates the need for an investigation of OFT-1 trajectory shaping criteria. The large variation of OFT-1 performance due to dispersions (figure 164) indicates the need for an OFT-1 FPR assessment.

5.7 GENERAL

Based on the results presented in this analysis (with appropriate consideration given to the aerodynamic data base), a change in the outboard elevon schedule is indicated. By changing the nominal schedule in the $M = 1.05$ to $M = 1.25$ region to slightly more positive deflection, the likelihood of outboard elevon hinge moment deflection for load relief due to winds or aerodynamic uncertainties will be reduced with only a minor impact on other load indicators and vehicle performance.

The sensitivity of the wing bending, shear, and FT01 structural load indicators to variations in inflight winds indicates a potential for updating the nominal ascent profile for both Missions 3A and OFT-1. By biasing the first stage ascent for a somewhat less negative $Q\alpha$ in the maximum dynamic pressure region ($M = 1.5$) it is possible to increase the FT01 indicator margin. However, since some reduction in wing root bending and wing shear margins will result, such a biasing update should only be considered within the context of the acceptability of the aerodynamic data base (IVBC-2) and the structural load indicator limits (reference 9) used in this analysis.

While the need for an FPR assessment for OFT-1 has already been established, the OFT-1 flight azimuth (for tracking) and main engine cutoff (MECO) (entry crossrange) constraints preclude a significant reduction in the sensitivity of OFT-1 vehicle performance to winds.

Overall, with due consideration given to the RSS combination of worst case winds with SSV system dispersions and aerodynamic variations, the results of this analysis indicate adequate margin on the vehicle subsystems for OFT-1.

6.0 SYMBOLS

F SSME	space shuttle main engine thrust, actual, lbs
HMI	inboard elevon hinge moment, in-lbs
HMO	outboard elevon hinge moment, in-lbs
HYDILD	hydraulic system fluid used, gallons, I = 1, 3
HYDIRT	hydraulic system fluid flow rate, gpm, I = 1, 3
INBELV	inboard elevon deflection, deg
LFT	left
LOXLD	liquid oxygen tank bulkhead load, lbs
OUTBEL	outboard elevon deflection, deg
RT	right
WRB	wing root bending moment, in-lbs
WRT	wing root torsion moment, in-lbs
WS	wing shear force, lbs
h, ALT	altitude, ft

p	body roll rate, deg/sec
Q , DYNPRS	dynamic pressure, psf
Q_α , QALFA	pitch aerodynamic load indicator, psf-deg
Q_β , QBETA	yaw aerodynamic load indicator, psf-deg
$\dot{q}$, HEATRT	convective stagnation heat rate indicator, Btu/ft ²
q_s , HEATLD	conective stagnation heat load indicator, Btu/ft ²
q	body pitch rate, deg/sec
r	body yaw rate, deg/sec
V_R , RELVEL	relative velocity, ft/sec
α	angle of attack, deg
β	angle of sideslip, deg
γ_R , FLTPTH	relative flight path angle, deg
ϕ , ROLLB	body roll attitude, deg

APPENDIX A.

OFT-1 WIND CRITERIA

In an effort to determine if additional subsystem margins could be obtained on OFT-1, the day of launch wind criteria was restricted to 50 percentile rather than the 95 percentile design vector wind envelope. The following discussion will assess only the impact of this reduced wind criteria on various vehicle and trajectory parameters. The groundrules for this analysis were the same as identified previously in figure 1 with the exception that ascent flight control 7 and IA81/IA135 load indicator coefficients (reference 16 and 17) were used.

Figures A-1 and A-2 are the squatcheloids at $M = 1.05$ and $M = 1.25$ which result from flying the OFT-1 profile in the presence of either 95 percentile vector winds or 50 percentile vector winds. The 95 percentile OFT-1 $Q\alpha/Q\beta$ span is about 600 psf-degrees less than Mission 3A (also see figure 45). By restricting the winds to a maximum of 50 percentile, an additional 800 psf-degrees reduction results. The variation of maximum dynamic pressure with squatcheloid angle (ψ) is shown in figures A-3 and A-4. These figures illustrate the reduced maximum dynamic pressure variation which results by restricting winds to the 50 percentile envelope (± 40 psf) instead of the 95 percentile design (± 80 psf). As shown in figure A-5, this reduced wind criteria corresponds to only about a 2 percent increase in flutter margin (27 percent with 95 percentile winds to 29 percent margin with 50 percentile).

The OFT-1 structural load indicators at $M = 1.05$ and $M = 1.25$ are given in figures A-6 to A-53 as a function of squatcheloid angle for the 95 and 50 percentile winds. In general, these figures show a margin increase (about 5 to 10 percent) on the structural load indicators (see figure A-54) from reducing the wind criteria to 50 percentile.

The SSV LOX bulkhead load indicator and hydraulic system requirements were found to be insensitive to a reduction in the inflight wind envelope criteria. Figures A-55 and A-56 give the sensitivity of maximum first stage stagnation heat rate to changes in wind direction for both 95 and 50 percentile winds. Figure A-57 summarizes the impact of wind criteria on first stage heating for the worst case wind.

The impact of inflight wind criteria on OFT-1 SRB staging conditions is shown in figure A-58. As expected the 50 percentile winds resulted in a smaller variation in the staging conditions than was seen with the 95 percentile winds.

In summary, all structural load indicator margins were increased by less than 10 percent. It should be noted that FT01, the only indicator previously shown to exceed allowable limits on OFT-1, did not realize any increase in margin as a result of inflight wind restrictions. However, the variations of

maximum dynamic pressure, first stage heating indicators, and SRB staging conditions with changes in wind direction were reduced about 50 percent by reducing the inflight wind criteria from 95 percentile to 50 percentile.

APPENDIX B

NOMINAL OFT-1 MAXIMUM DYNAMIC PRESSURE

The Launch Analysis Section has completed a preliminary analysis of the impact of increasing the nominal maximum dynamic pressure on OFT-1 from 550 psf (baseline) to 600 psf.

The groundrules for this analysis were the same as identified previously in figure 1 with the exception that ascent flight control 7 and IA81/IA135 load indicator coefficients were used. Also, the SSME throttle level and staging flight path angle were optimized for a 600 psf maximum dynamic pressure trajectory profile (reference 18).

A comparison of several trajectory and vehicle parameters which resulted from nominal OFT-1 launch trajectories with a 500 psf and a 600 psf maximum dynamic pressure is given in figure B-1. This comparison shows that while a $Q_{\max} = 600$ psf profile has significantly less SSME throttle requirement, it does result in a somewhat more lofted trajectory and significantly higher first stage stagnation heat rate.

Figure B-2 presents the squatcheloid at $M = 1.05$ which results from flying a nominal OFT-1 profile with $Q_{\max} = 550$ psf or $Q_{\max} = 600$ psf in the presence of 95 percentile vector winds. As can be seen, the Q_{α}/Q_{β} span from the 600 psf profile is about 75 psf-degrees larger than the 550 psf nominal ascent profile. The variation of maximum dynamic pressure with squatcheloid angle (ψ , defined in figure B-2) is shown in figure B-3. By comparing figures B-2 and B-3, it is possible to determine that the higher nominal dynamic pressure profile results in α and β variations due to winds which are about the same as the 550 psf ascent profile. Figure B-4 illustrates the flutter margin which results from worst case headwinds for a 600 psf nominal $Q_{\max}$ (17 percent) and a 550 psf nominal $Q_{\max}$ (27 percent) ascent trajectory profile.

The variation of the OFT-1 structural load indicators with wind direction is given in figures B-5 through B-28 for the 600 psf and 550 psf nominal $Q_{\max}$ trajectory profiles. The minimum margins due to winds are summarized in figure B-29. In general, the load indicators from the 600 psf nominal $Q_{\max}$ trajectory do not exhibit any definite trend towards increased or decreased margins relative to the 550 psf profile. However, several of the thrust dependent indicators (FT07, FT08, FTB5, FTB6) have increased margins (on the 600 psf profile) as a result of the reduced SSME throttle requirements exhibited by the higher nominal dynamic pressure trajectory.

The variations of the first stage stagnation heating indicators and the SRB staging conditions with changes in wind direction are presented in figures B-30 and B-31 respectively.

In summary, the results of this analysis show that the variations of structural load indicators and trajectory parameters with changes in wind direction are about the same for both a 550 psf and 600 psf nominal ascent trajectory. While the 600 psf nominal dynamic pressure profile would significantly reduce the SSME throttle requirements for OFT-1, it would also increase the first stage heating by 50 percent and decrease the flutter margin by 10 percent (about a 55 psf increase in the maximum expected dynamic pressure due to winds).

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16. McDonnell Douglas Technical Memorandum No. 1.2-TM-B0105-376, "Ascent Airloads Data Tape V08858", August 1, 1975.
17. McDonnell Douglas Technical Memorandum No. 1.2-TM-B0105-760, "Split Elevon Component Loads Data - IA135", May 28, 1976.
18. Costigan, M." "OFT-1 Trajectory Shaping", JSC Memorandum EX42/7612-143, January 31, 1977.

FIGURE 1.- ASSUMPTIONS AND GROUND RULES

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- CANDIDATE OFT-1 ASCENT TRAJECTORY PROFILE, REFERENCE 1
- MISSION 3A ASCENT TRAJECTORY PROFILE, REFERENCE 2
- MATED VEHICLE MASS PROPERTIES PER THE SHUTTLE OPERATIONAL DATA BOOK, REFERENCE 3
- BASELINE ASCENT FLIGHT CONTROL SYSTEM 8 (FCS8), REFERENCE 4
- MATED VEHICLE AERODYNAMIC DATA (IVBC#2) PER THE DECEMBER, 1976 AERODYNAMIC DESIGN DATA BOOK, VOLUME II, REFERENCE 5
- PROGRAMMED ELEVON SCHEDULE 6, FIGURE 2
- VECTOR WIND MODEL, REFERENCE 6- 8
- ELEMENT DATA FOR STRUCTURAL LOAD INDICATORS AS GIVEN IN REFERENCE 5
- STRUCTURAL LOAD INDICATOR LIMITS (WING/ELEVON) AS GIVEN IN REFERENCE 4, SEE FIGURE 4
- STRUCTURAL LOAD INDICATOR LIMITS (ATTACH POINT) AS GIVEN IN REFERENCE 9, SEE FIGURE 4 AND 5
- DISPERSIONS
 - a) MATED VEHICLE AERODYNAMIC VARIATIONS ON OFT-1 AS GIVEN IN REFERENCE 10
 - b) MATED VEHICLE AERODYNAMIC TOLERANCES ON MISSION 3A, REFERENCE 5
 - c) SRB THRUST MISMATCH WITH PROPELLANT MEAN BULK TEMPERATURE CORRELATION AS GIVEN IN REFERENCE 11
 - d) $\pm 4.9\%$ SRB WEB ACTION TIME (HOT/COLD SRB)
 - e) ELEVON HINGE MOMENT VARIATIONS ON OFT-1, REFERENCE 10
 - f) ELEVON HINGE MOMENT TOLERANCES ON MISSION 3A, REFERENCE 12
 - g) PLATFORM MISALIGNMENT = ± 0.5 (ATTITUDE ERROR)
 - h) ACCELEROMETER ERROR SOURCES COMBINED PER THE MINUTES OF THE 11th ASCENT PERFORMANCE PANEL, REFERENCE 13
 - i) STRUCTURAL LOAD INDICATORS ELEMENT AERODYNAMIC VARIATIONS ON OFT-1, REFERENCE 14
 - j) STRUCTURAL LOAD INDICATORS ELEMENT AERODYNAMIC TOLERANCES ON MISSION 3A, REFERENCE 5

FIGURE 2.- ELEVON SCHEDULE 6 - MISSION 3A AND OFT-1

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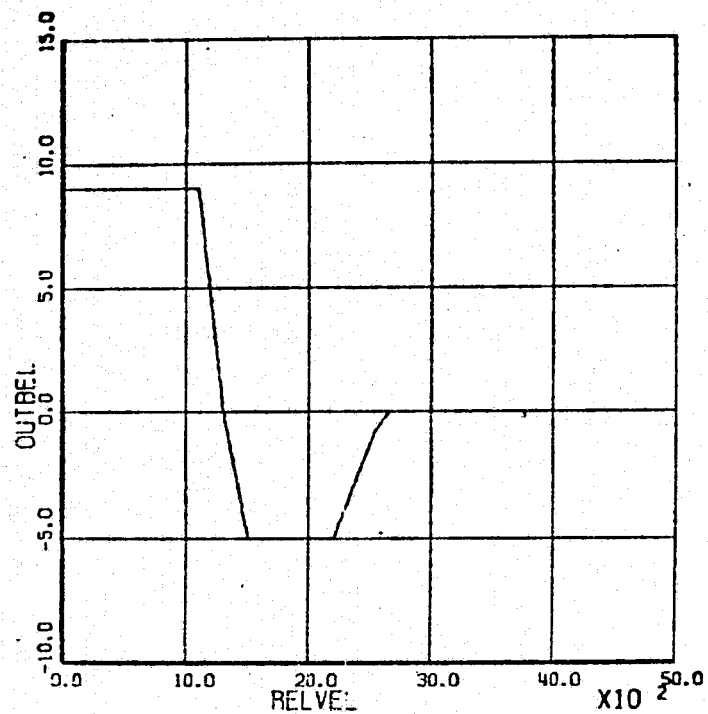
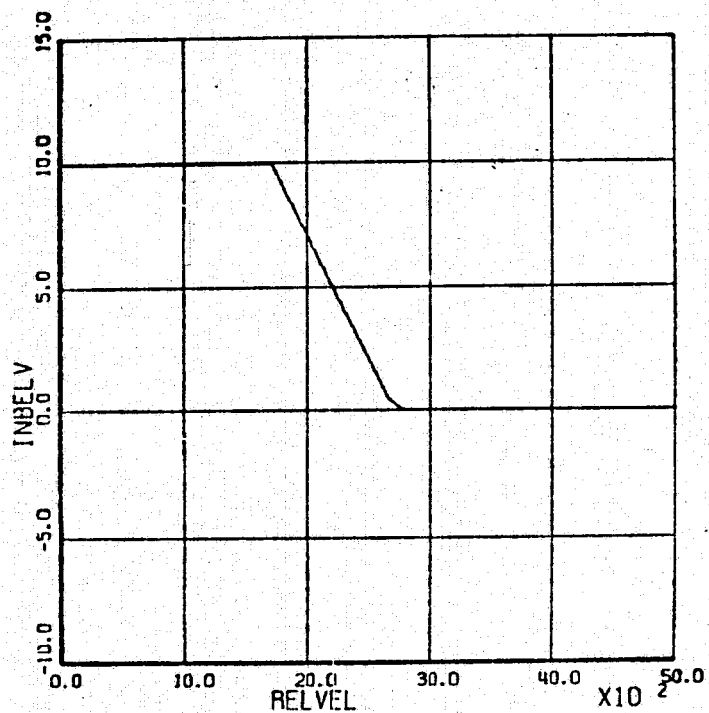


FIGURE 3.- OFT-1/MISSION 3A SSME THRUST PROFILES

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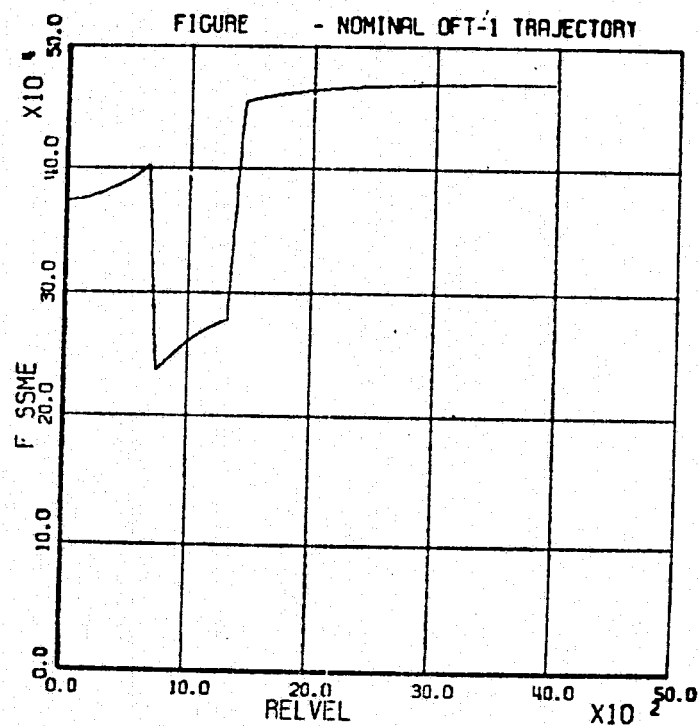
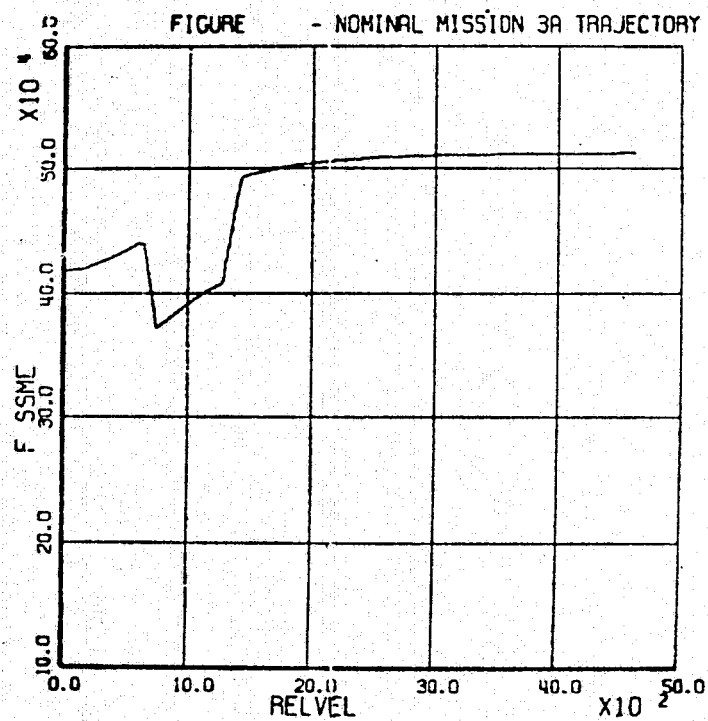


FIGURE 4.- STRUCTURAL LOAD INDICATOR LIMITS

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LOAD INDICATOR	MAXIMUM LIMIT	MINIMUM LIMIT
WING ROOT BENDING, IN-LBS	32X10 ⁶	-17X10 ⁶
WING SHEAR, LBS	190,000	0
WING ROOT TORSION, IN-LBS	17X10 ⁶	- -
OUTBOARD ELEVON HINGE MOMENT, IN-LBS	415,000	-357,000
INBOARD ELEVON HINGE MOMENT, IN-LBS	870,000	-700,000
FT01, FORWARD Z, LBS	119,000	-143,000
FT02, FORWARD Y, LBS	91,000	-86,000
FT03, AFT LEFT Z, LBS	315,000	-463,000
FT04, AFT RIGHT Z, LBS	354,000	-394,000
FT06, AFT RIGHT Y, LBS	107,000	-107,000
FT07, AFT LEFT X, LBS	131,000	-719,000
FT08, AFT RIGHT X, LBS	131,000	-719,000
FTB1, FORWARD LEFT Z, LBS	195,000	-202,000
FTB2, FORWARD RIGHT Z, LBS	195,000	-202,000
FTB3, FORWARD LEFT Y, LBS	232,000	-84,000
FTB4, FORWARD RIGHT Y, LBS	84,000	-232,000
FTB5, FORWARD LEFT X, LBS	177,000	-1.591X10 ⁶
FTB6, FORWARD RIGHT X, LBS	177,000	-1.584X10 ⁶
FTB7, AFT LEFT Z, LBS	279,000	-211,000
FTB8, AFT RIGHT Z, LBS	277,000	-229,000
FTB9, AFT LEFT Y, LBS	206,000	-348,000
FTB10, AFT RIGHT Y, LBS	348,000	-206,000
MTB1, LEFT SRB MOMENT, IN-LBS	21.2X10 ⁶	-25.3X10 ⁶
MTB2, RIGHT SRB MOMENT, IN-LBS	25.3X10 ⁶	-21.2X10 ⁶
LOX BULKHEAD LOAD, LBS	3.18X10 ⁶	0

FIGURE 5. - EXTERNAL TANK ATTACH LOADS AND DIRECTIONS

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SECTIONS LOOKING FORWARD
ALL LOADS APPLIED TO THE TANK
POSITIVE DIRECTIONS SHOWN

ALL ODD FTB'S = LEFT
ALL EVEN FTB'S = RIGHT

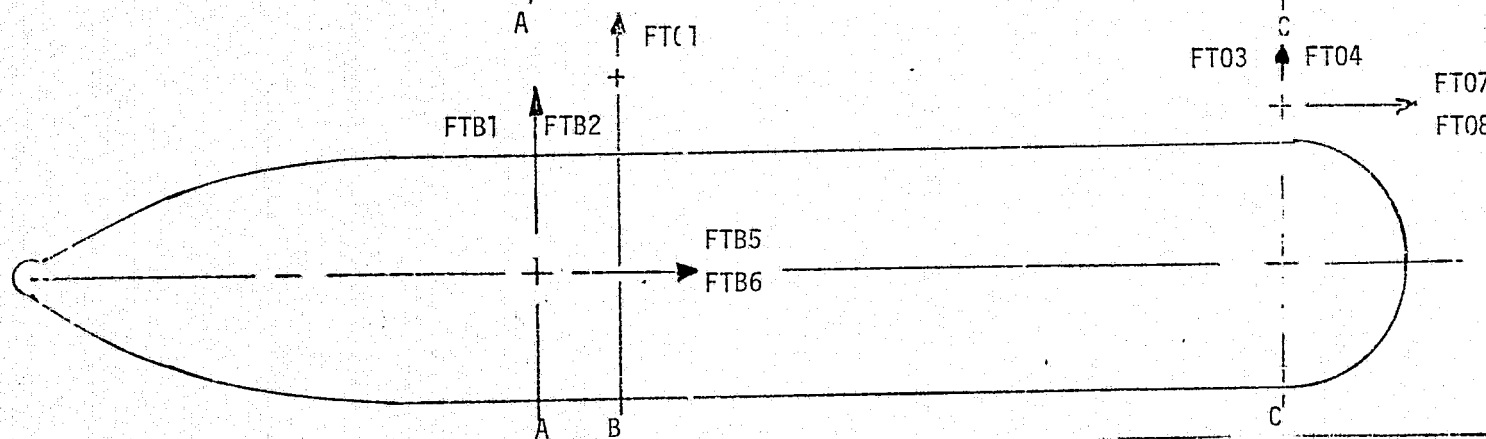
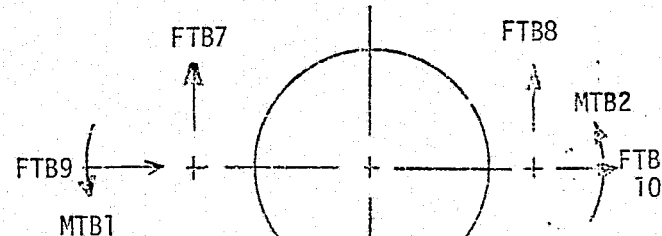
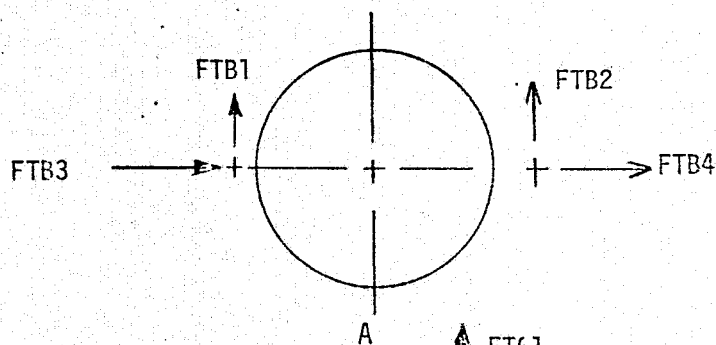
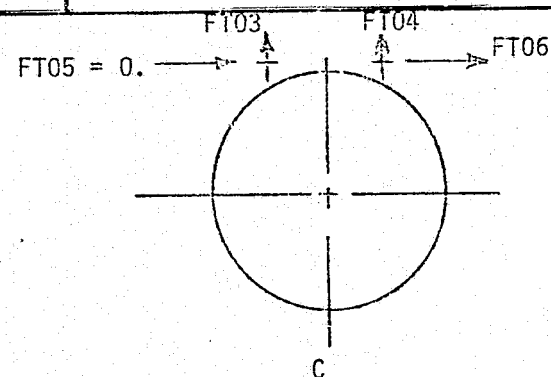
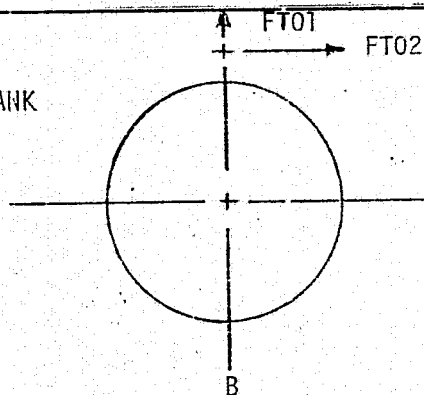


FIGURE 6.- METHOD USED TO COMBINE DISPERSIONS

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AT A GIVEN MACH NUMBER:

$$\text{MAXIMUM/MINIMUM LOAD} = \text{MWN} \pm \sqrt{(\Delta W)^2 + (\Delta D)^2 + (\Delta E)^2}$$

WHERE:

MWN = Mean wind nominal value at given Mach number

ΔW = Difference between MWN and value of indicator in the presence of 95 percentile winds with 99% shear and 9 m/sec gust with the 0.85 factor included.

ΔD = Difference between MWN and value of indicator in the presence of the SSV system dispersions.

ΔE = Difference between MWN and value of indicator in the presence of the element aerodynamic uncertainties.

FIGURE 7.- NOMINAL DYNAMIC PRESSURE (Q) COMPARISON

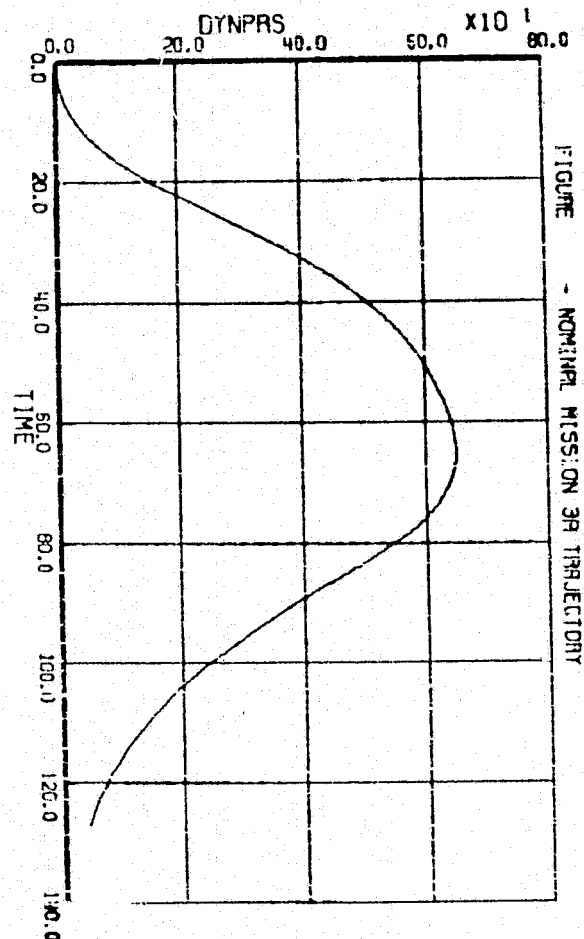
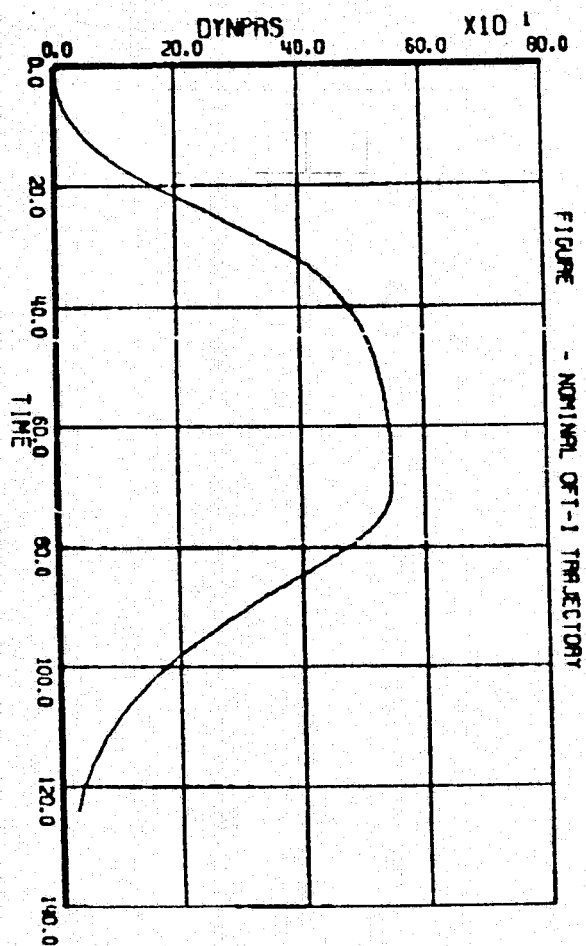
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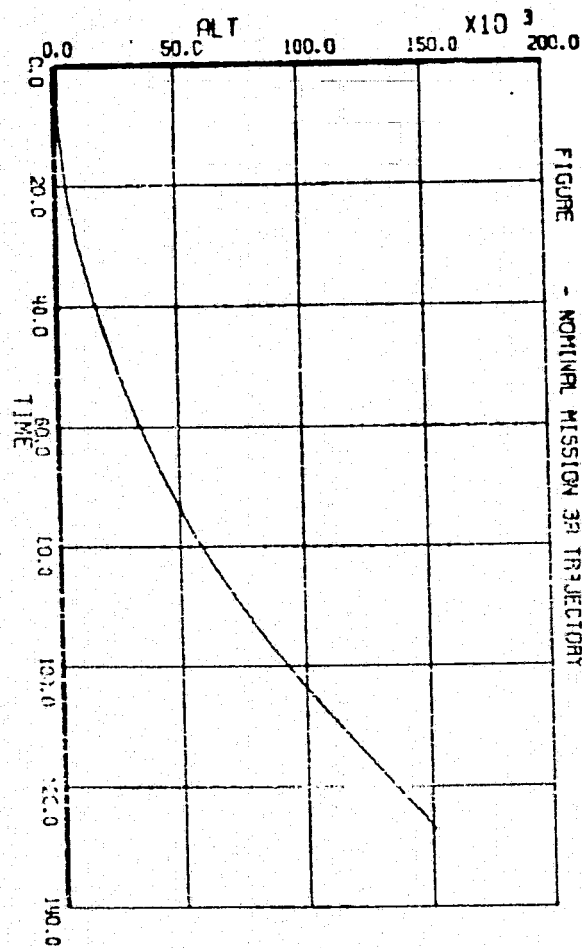
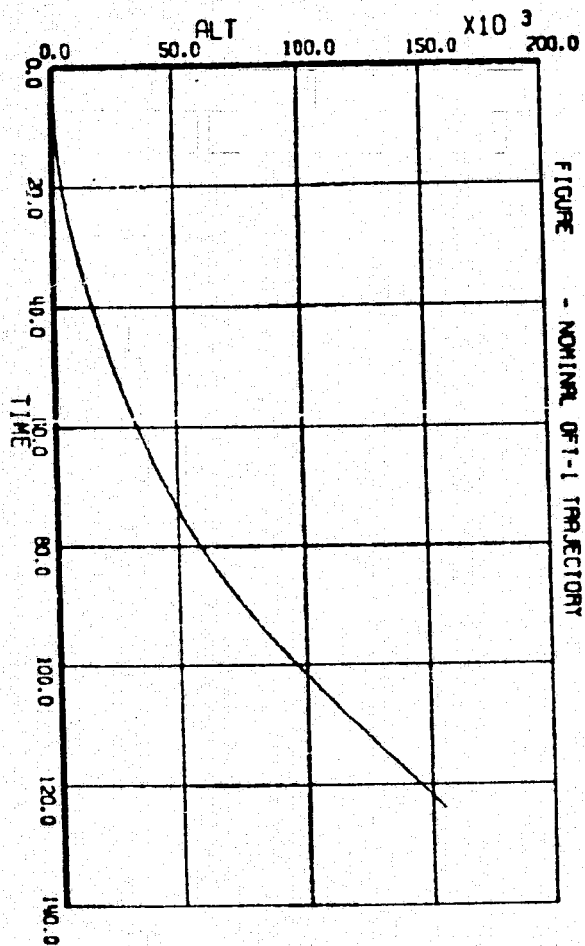
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FIGURE 8.- NOMINAL ALTITUDE COMPARISON

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FIGURE 9.- NOMINAL RELATIVE VELOCITY COMPARISON

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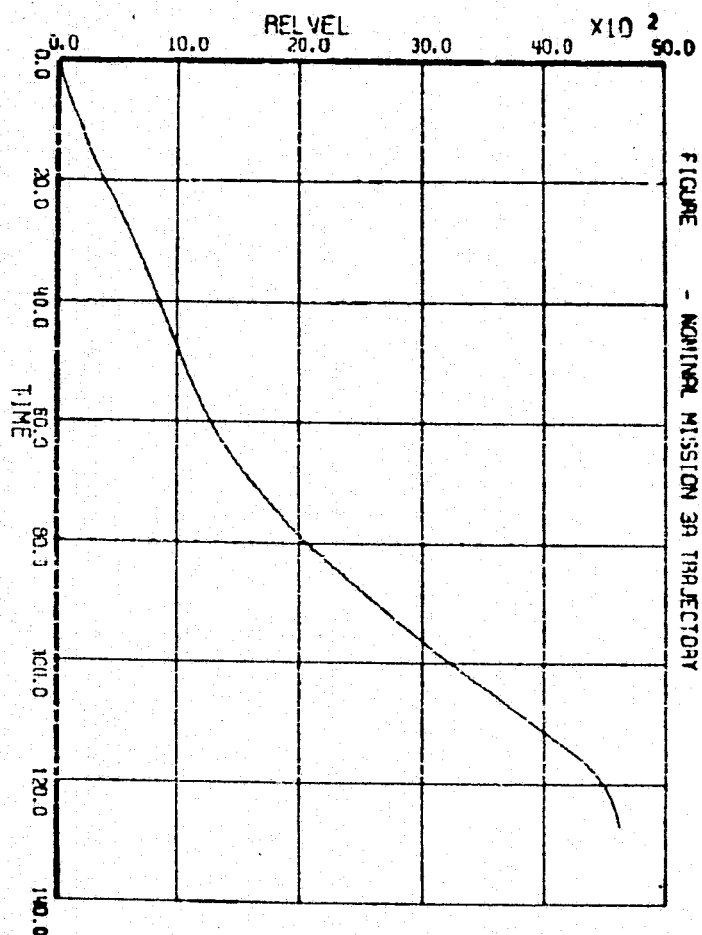
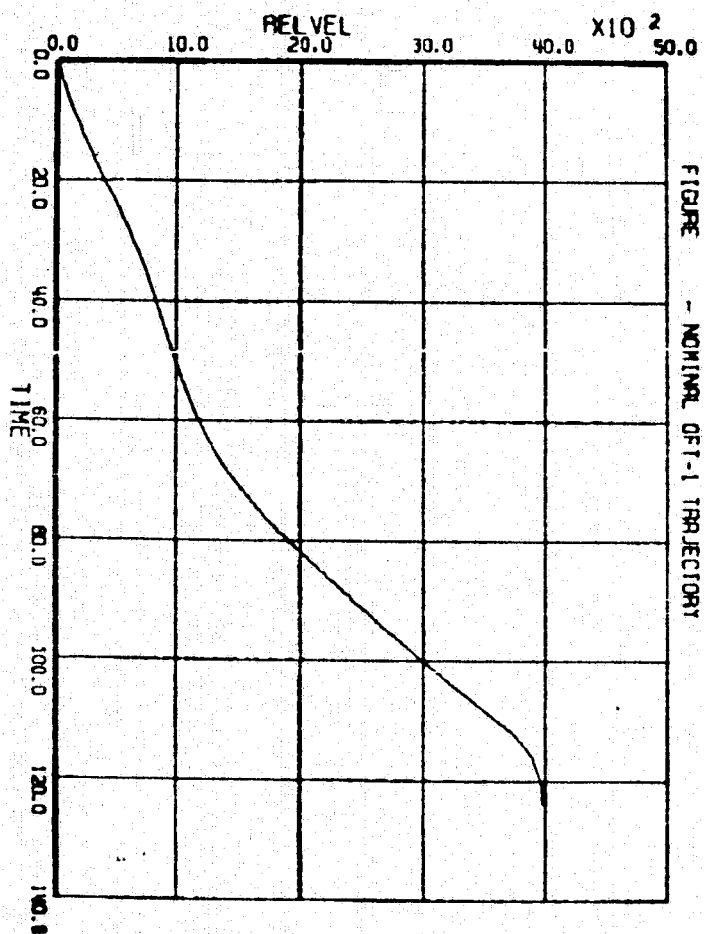


FIGURE 10.- NOMINAL FLIGHT PATH ANGLE COMPARISON

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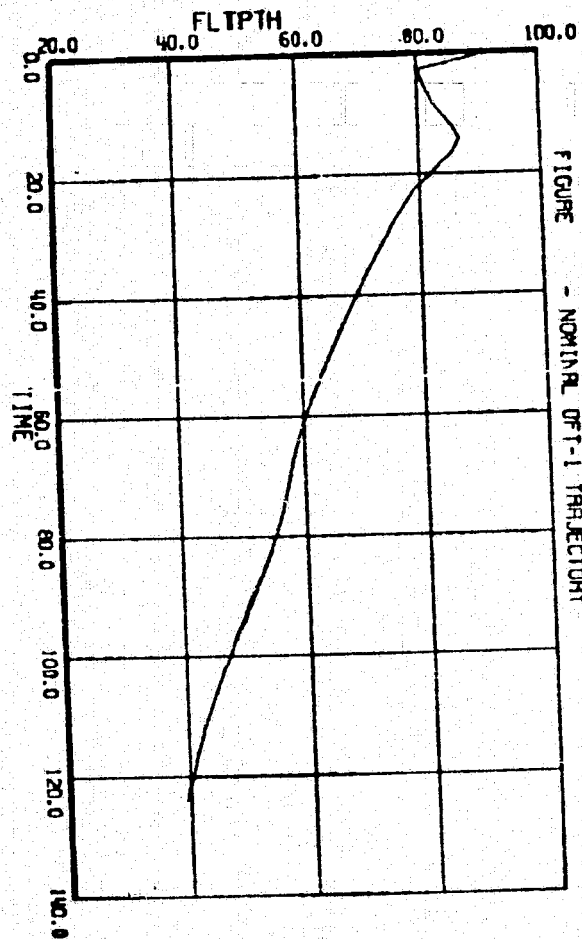


FIGURE 10 - NOMINAL DT-1 TRAJECTORY

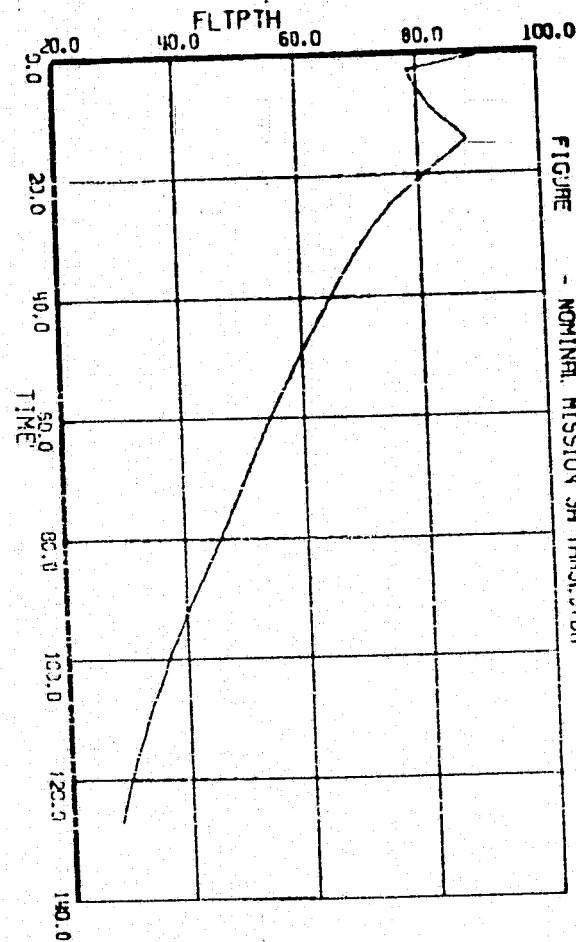


FIGURE 10 - NOMINAL MISSION 3A TRAJECTORY

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FIGURE 11.- NOMINAL ALPHA PROFILES

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FIGURE - NOMINAL MISSION 3A TRAJECTORY

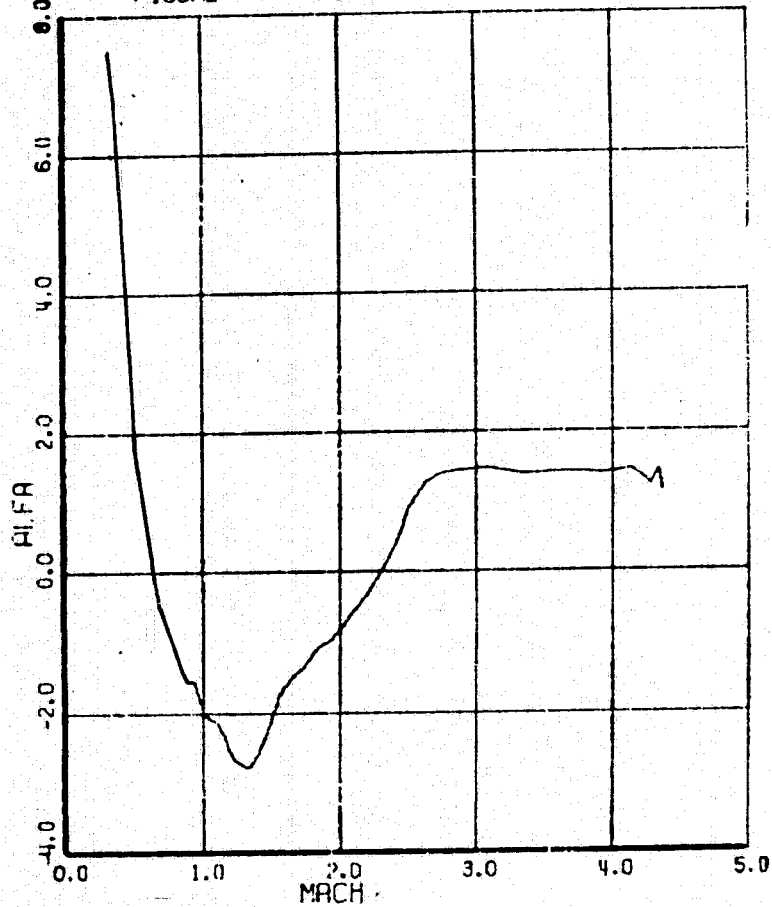
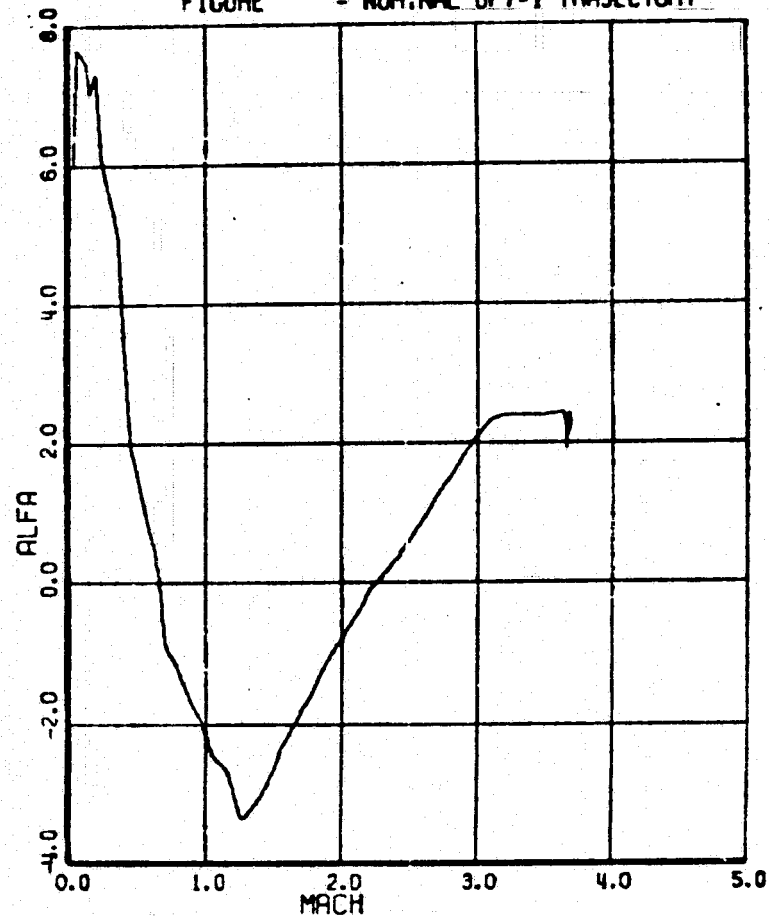


FIGURE - NOMINAL OFI-1 TRAJECTORY

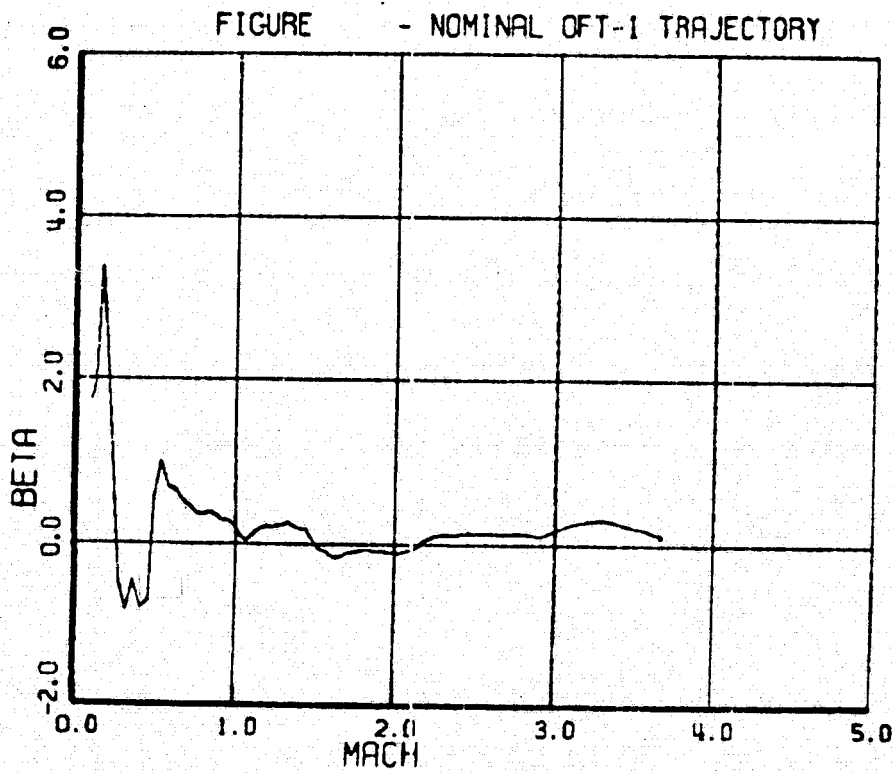
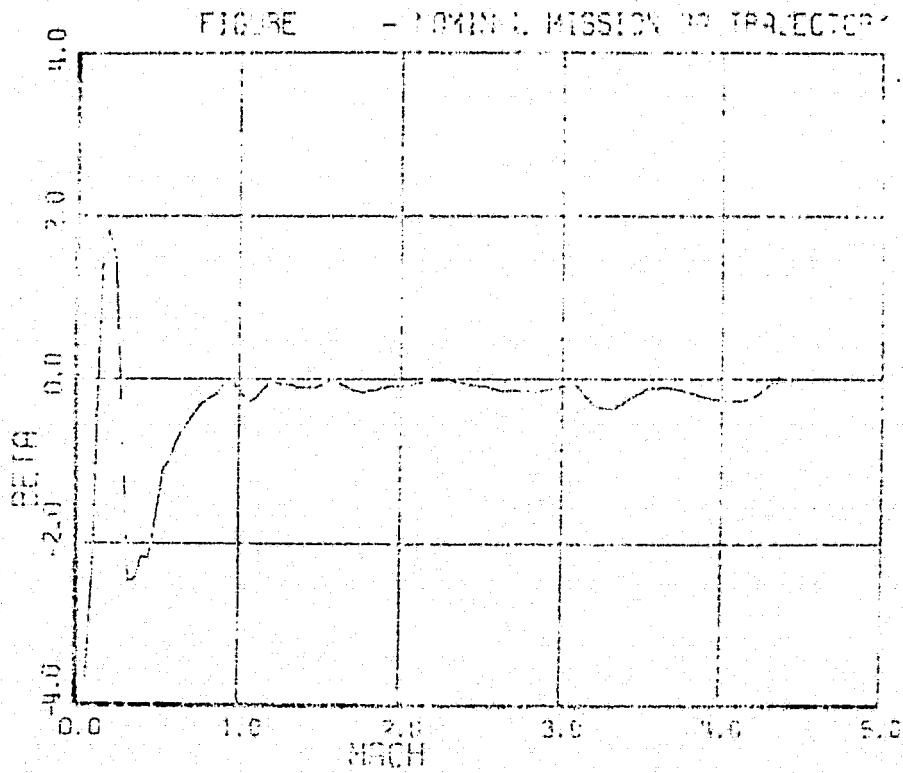


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FIGURE 12.- NOMINAL BETA PROFILES



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FIGURE 13.- NOMINAL BODY ROLL ANGLE COMPARISON

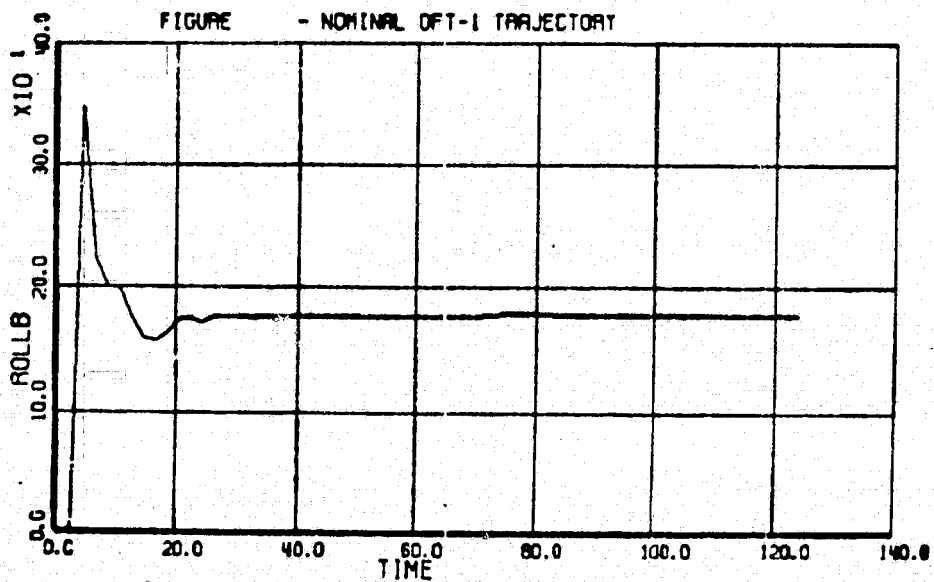
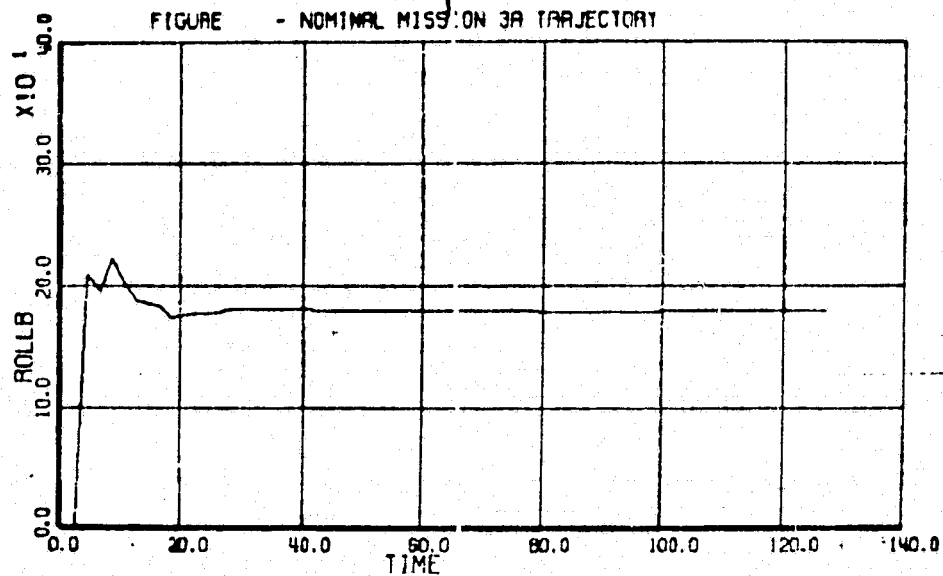


FIGURE 14.- NOMINAL Q*ALPHA PROFILE COMPARISON

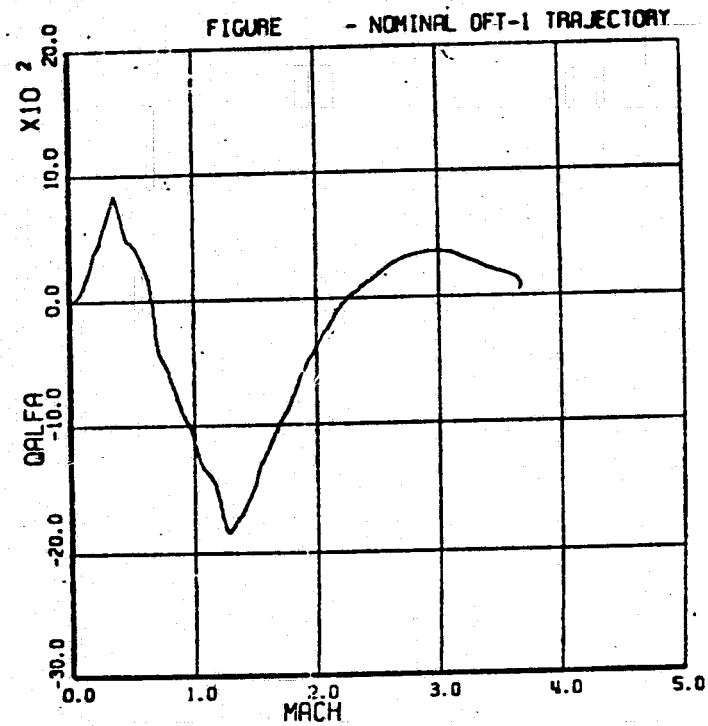
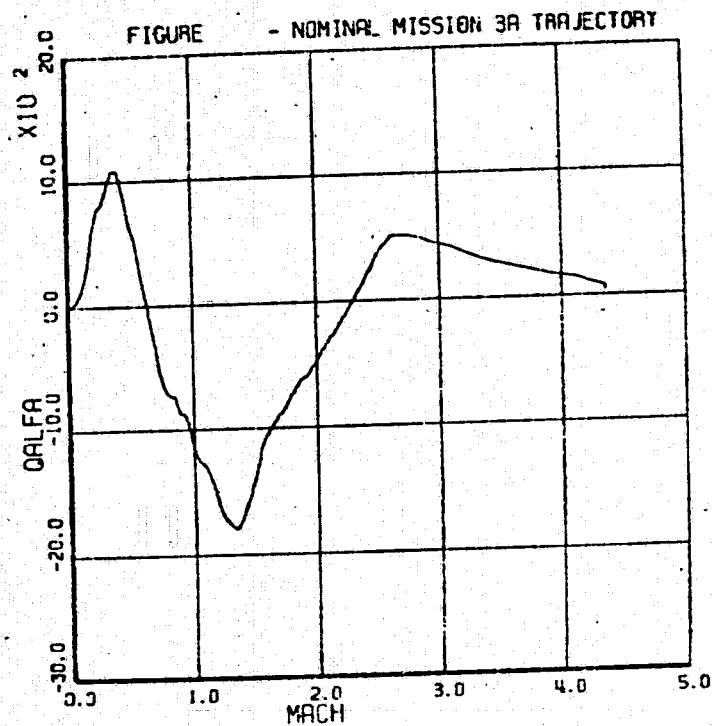
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FIGURE 15.- NOMINAL Q*BETA PROFILE COMPARISON

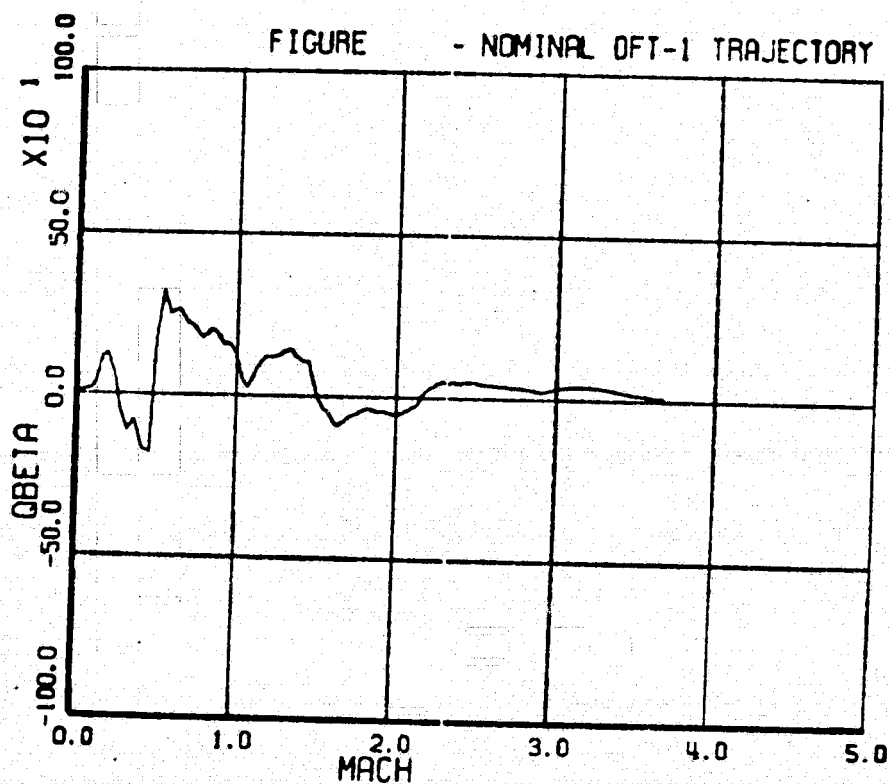
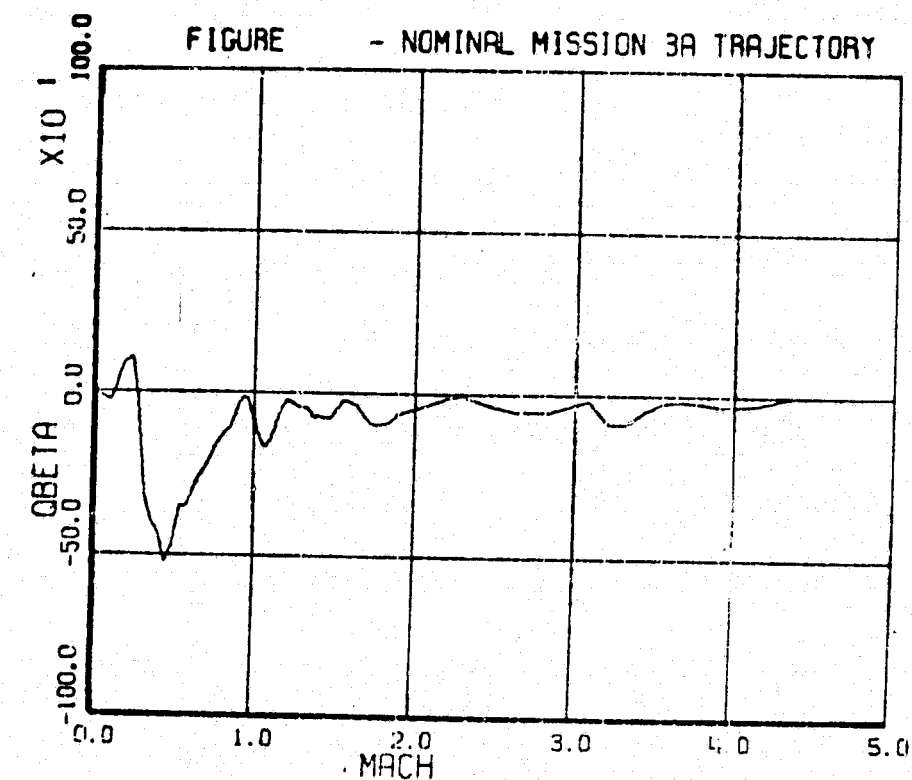
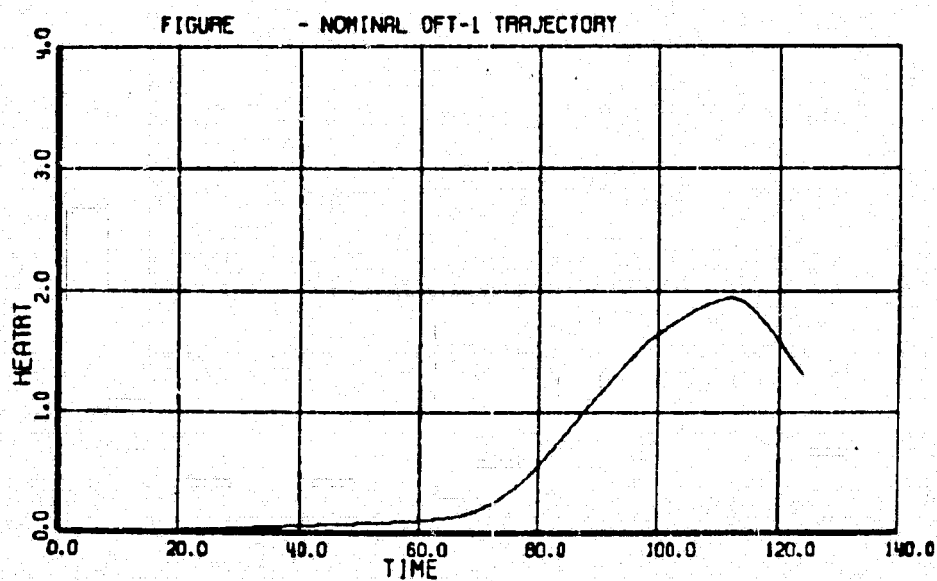
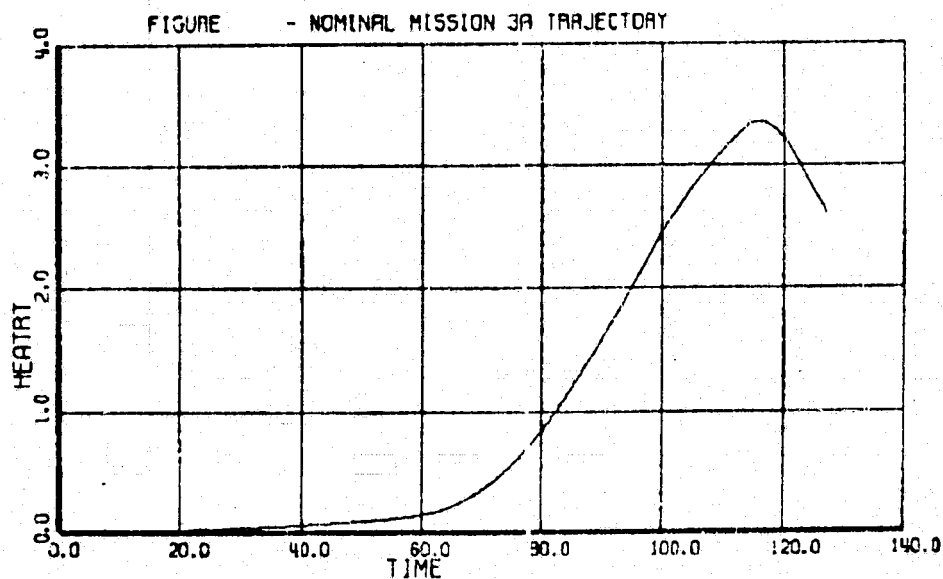


FIGURE 16.- NOMINAL STAGNATION HEAT RATE

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FIGURE 17.- NOMINAL STAGNATION HEAT LOAD INDICATOR

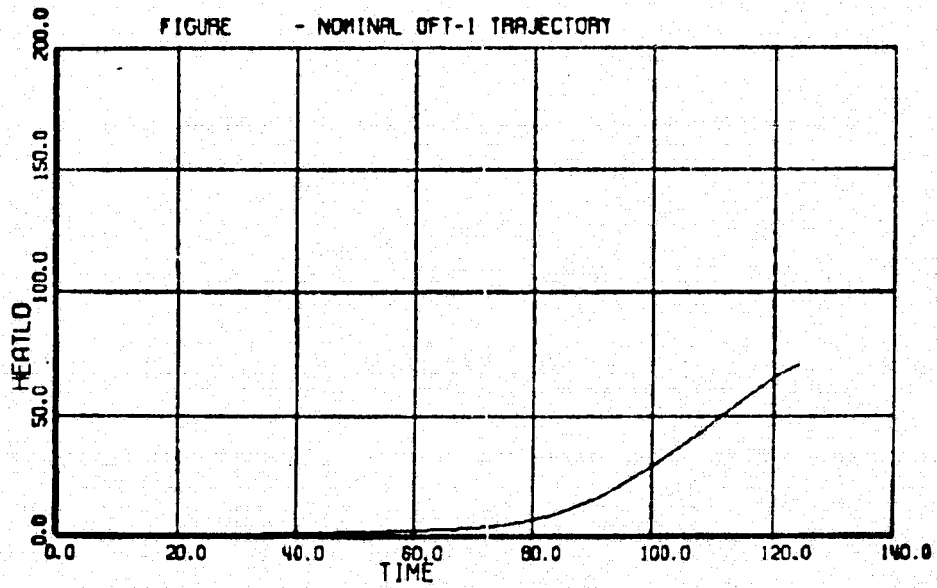
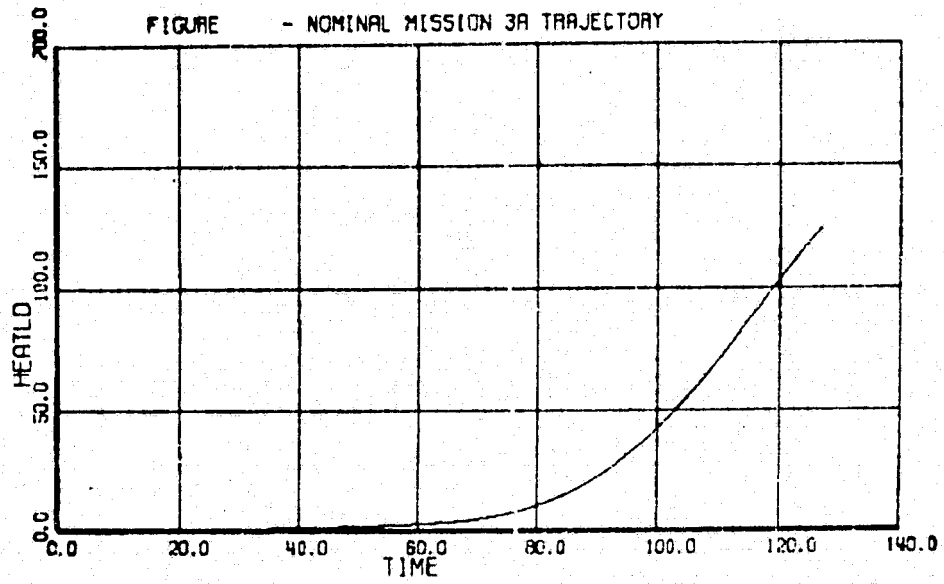


FIGURE 18.- NOMINAL OFT-1 HYDRAULIC SYSTEMS FLOW REQUIREMENTS

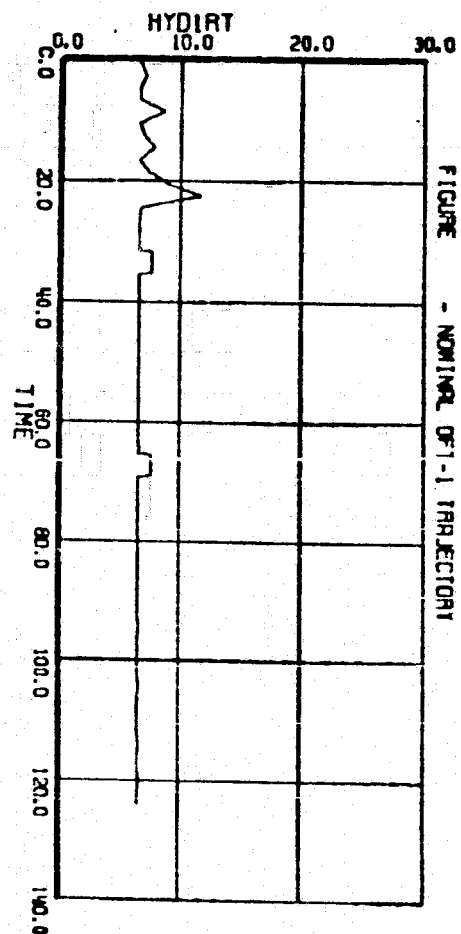
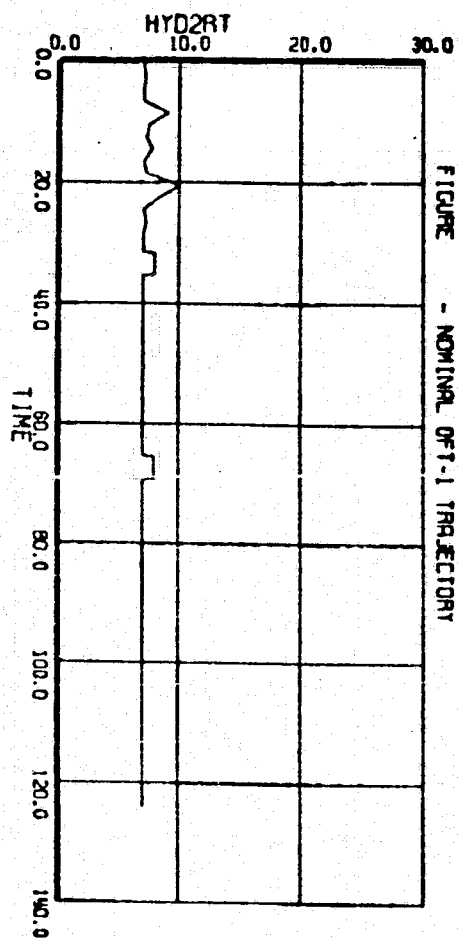
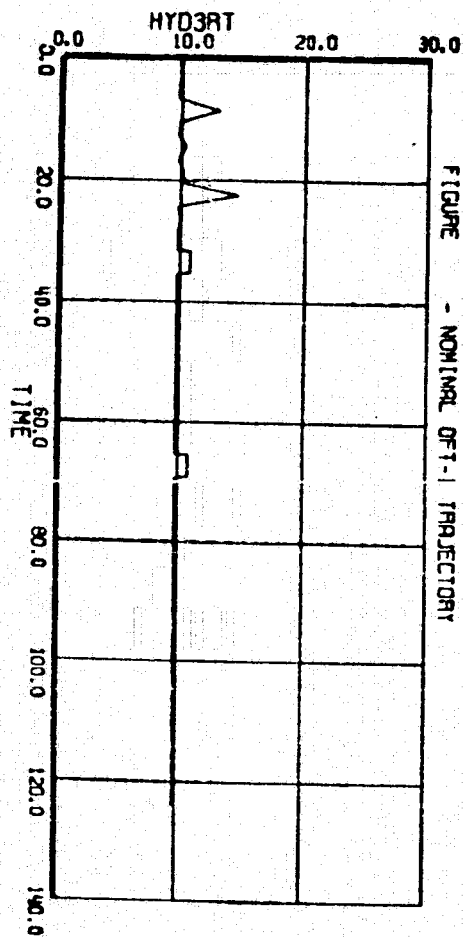
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FIGURE 19.- NOMINAL OFT-1 HYDRAULIC SYSTEMS FLUID USAGE

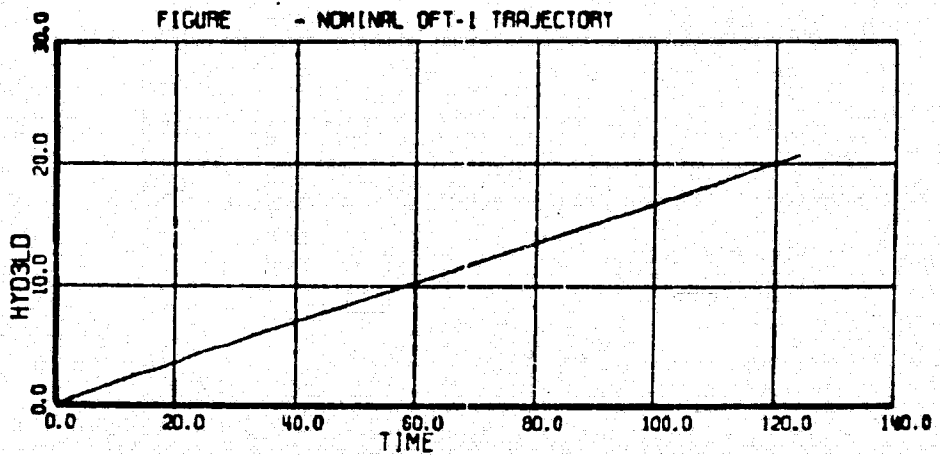
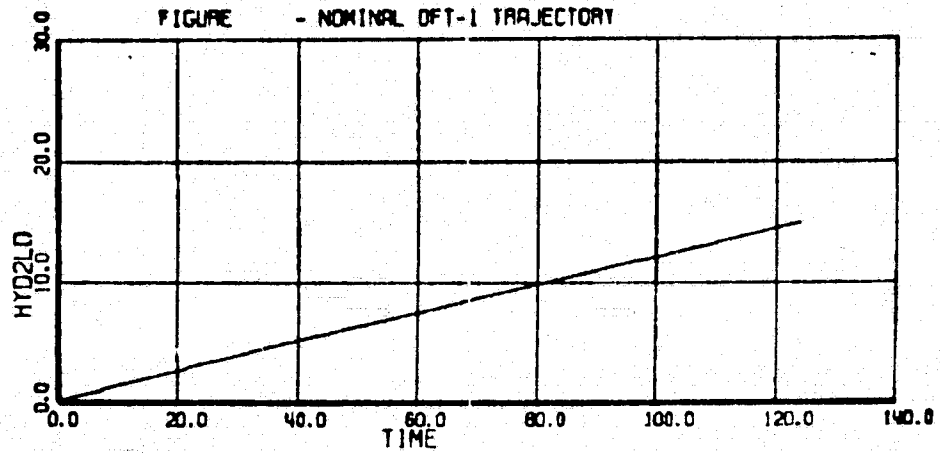
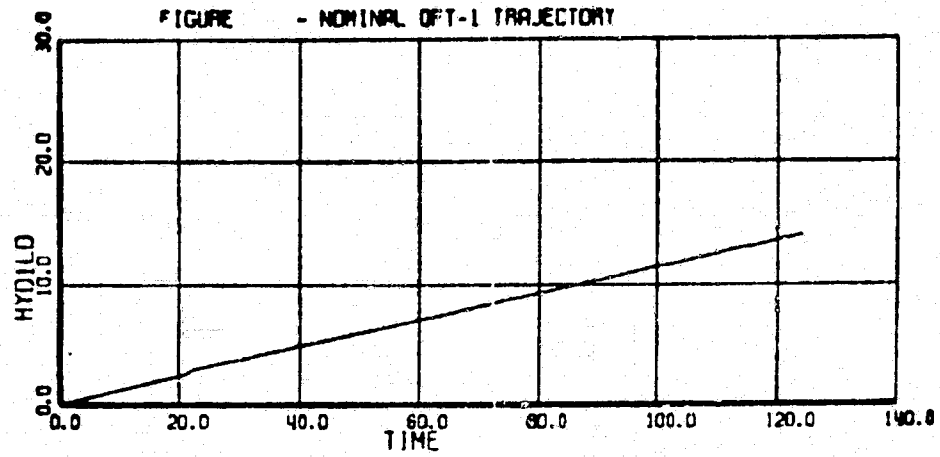
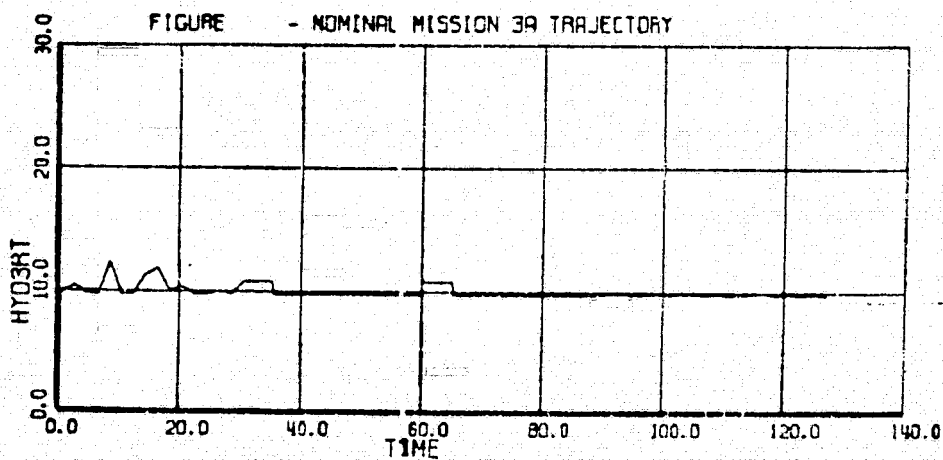
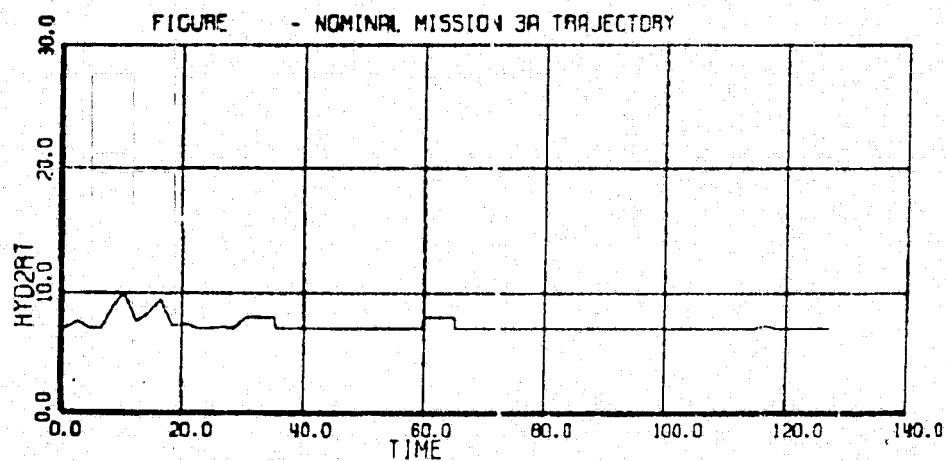
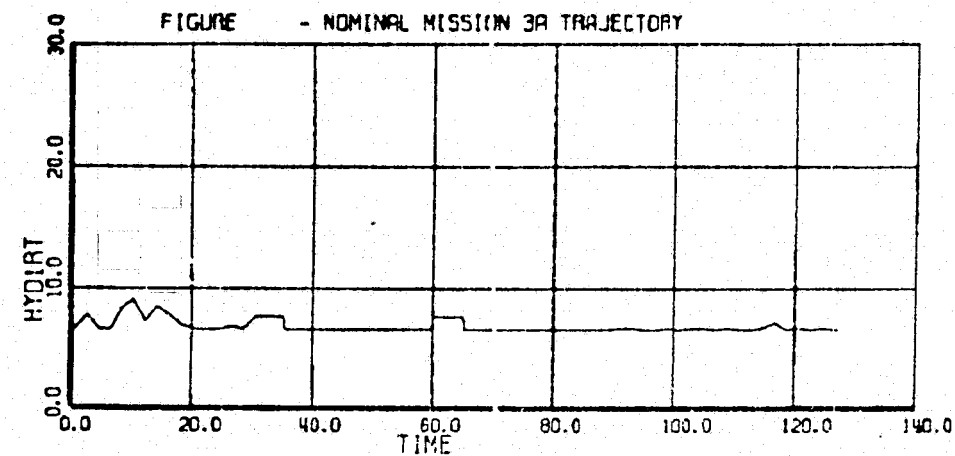


FIGURE 20.- NOMINAL 3A HYDRAULIC SYSTEMS FLOW REQUIREMENTS



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FIGURE 21.- NOMINAL 3A HYDRAULIC SYSTEMS FLUID USAGE

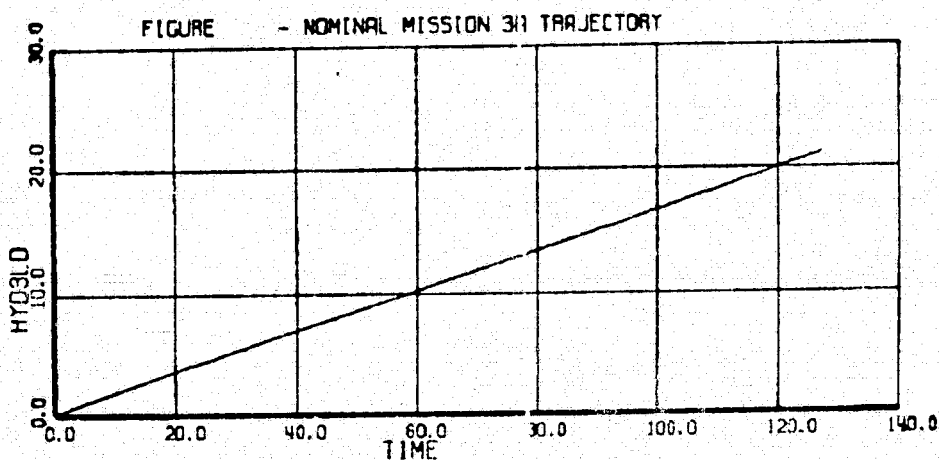
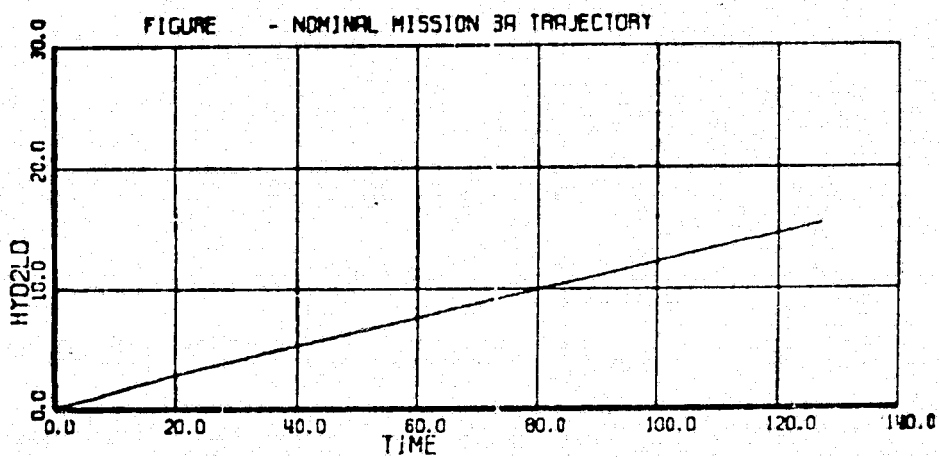
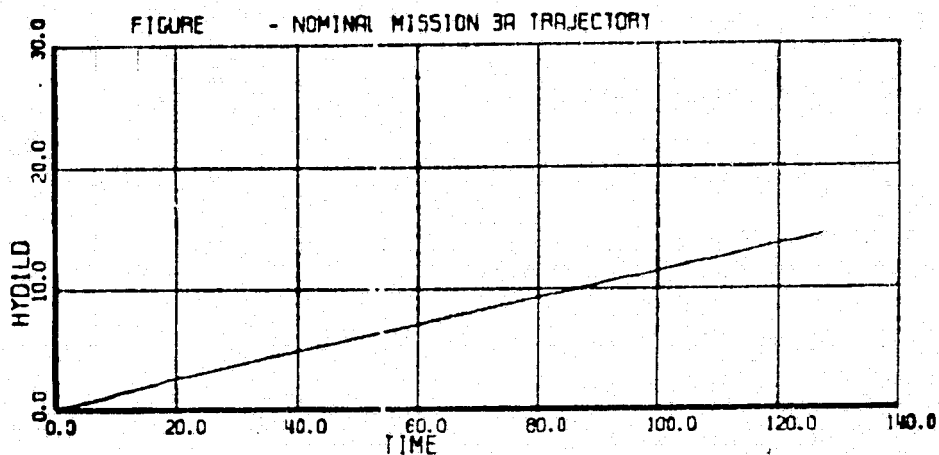


FIGURE 22.- NOMINAL LOX BULKHEAD LOAD INDICATOR

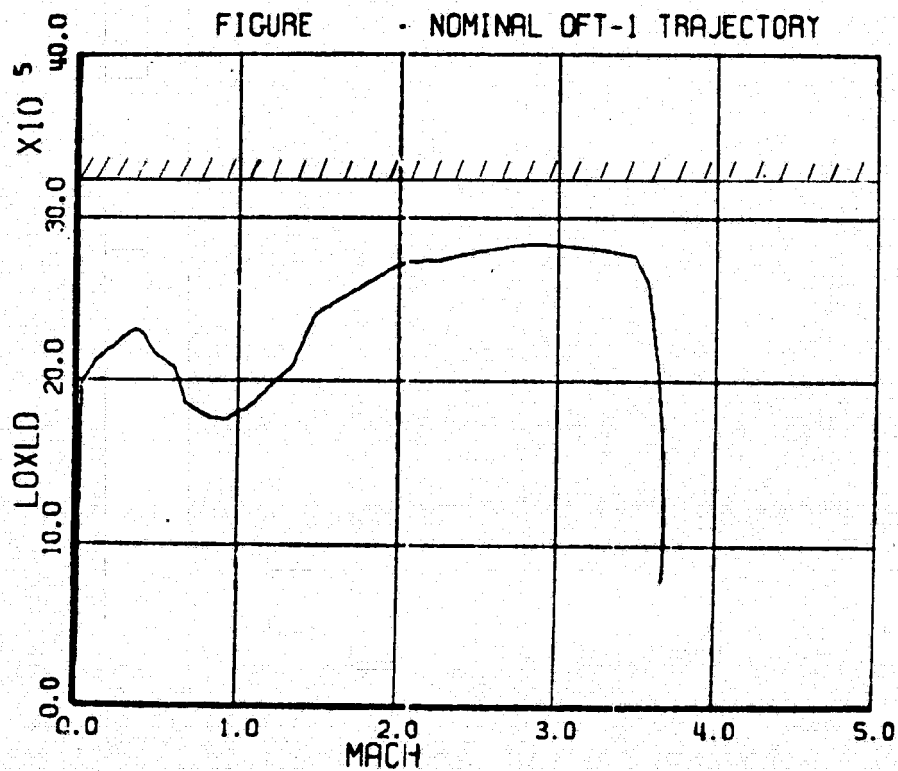
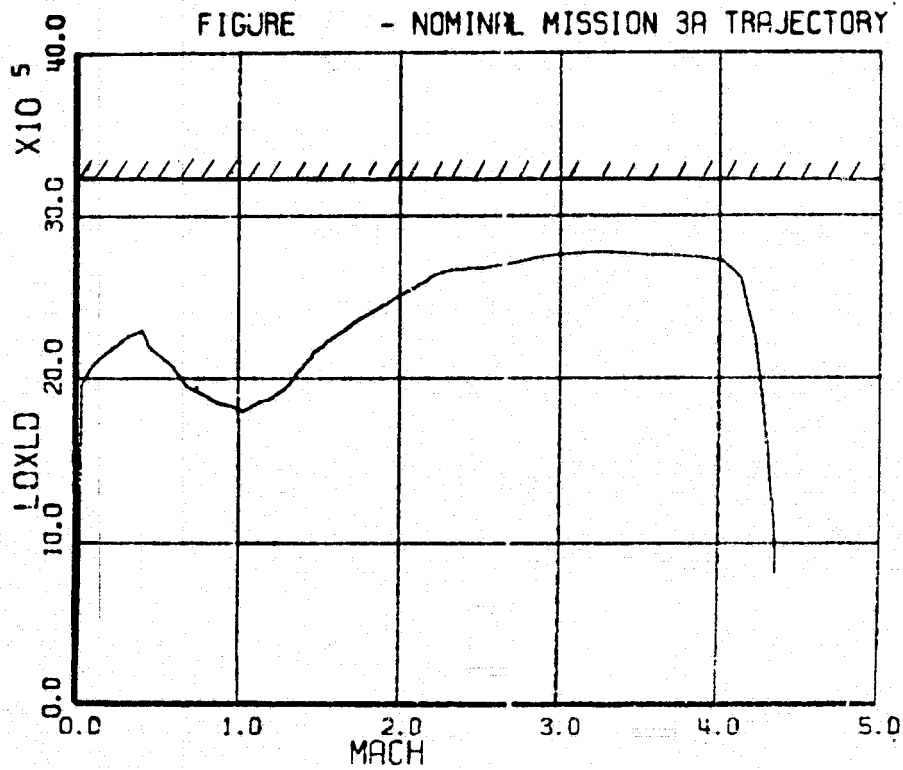


FIGURE 23.- NOMINAL WING ROOT BENDING MOMENT

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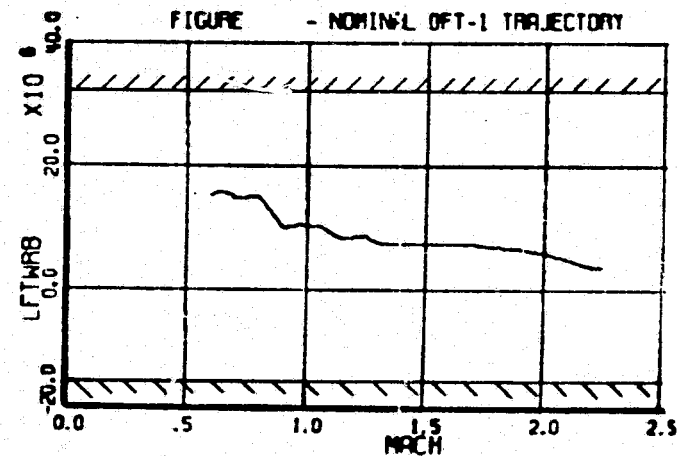
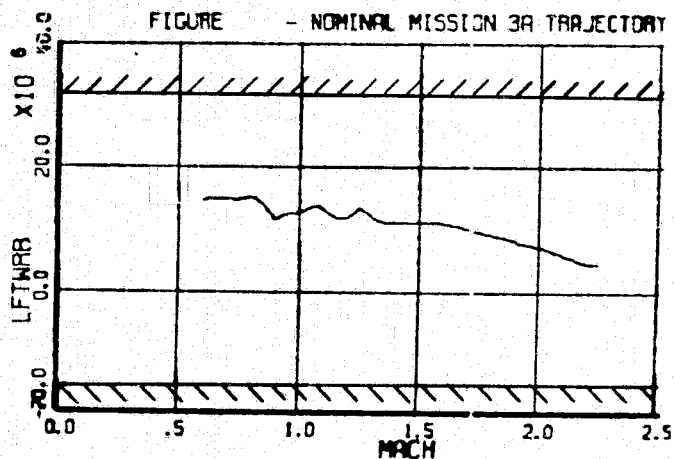
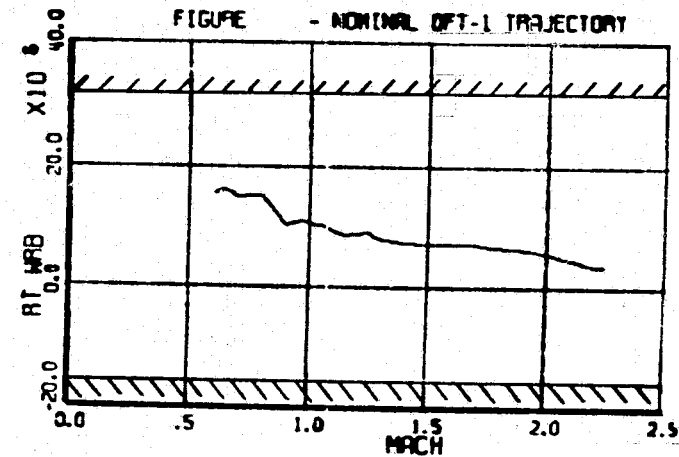
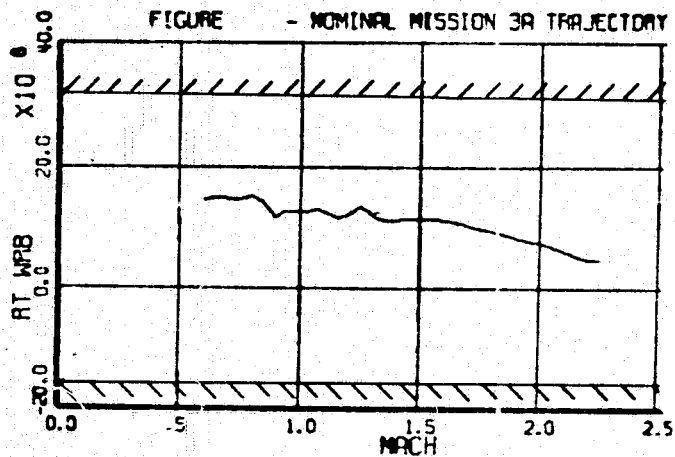


FIGURE 24.- NOMINAL WING ROOT TORSION MOMENT

ENGINEERING ANALYSIS DIVISION/EX

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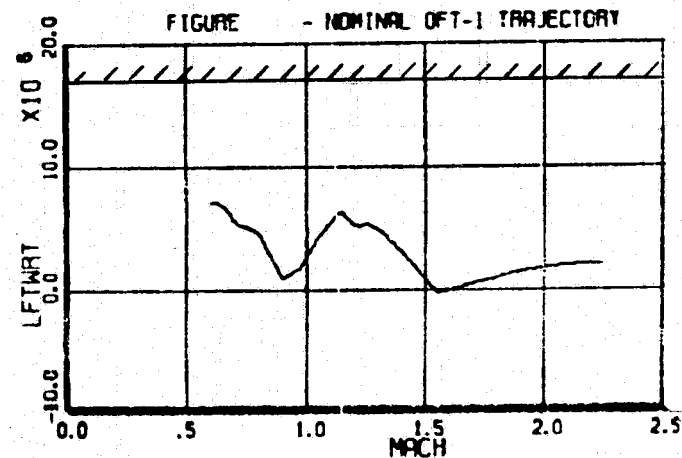
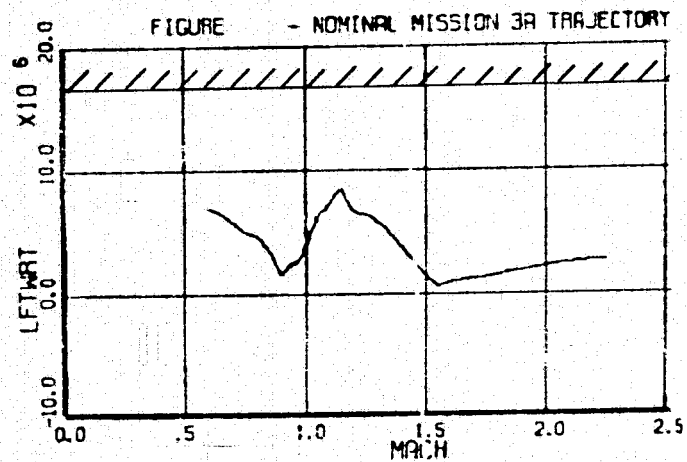
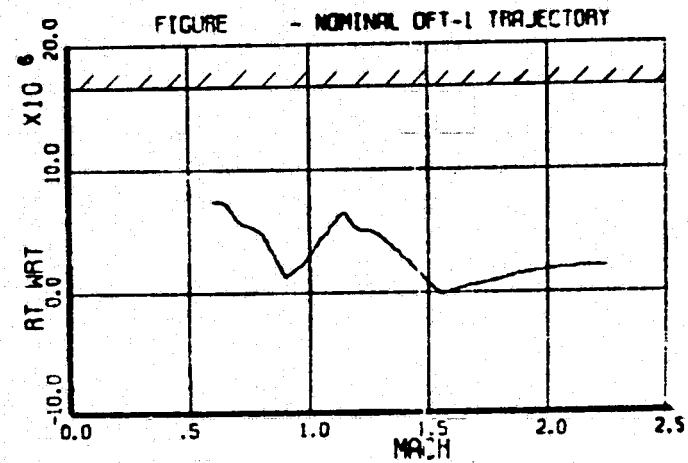
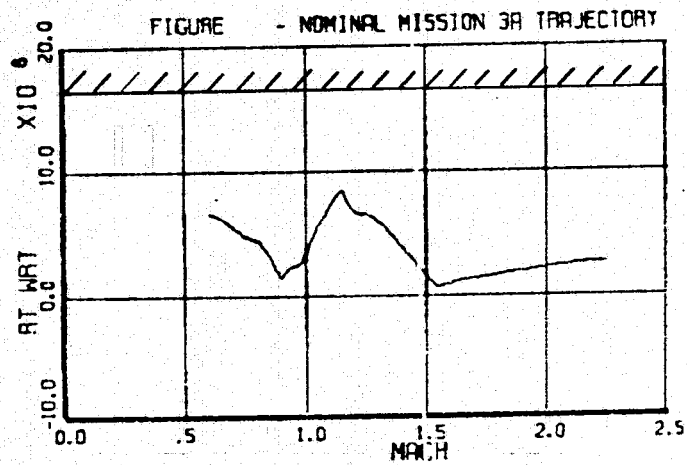


FIGURE 25.- NOMINAL WING SHEAR FORCE

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DATE _____

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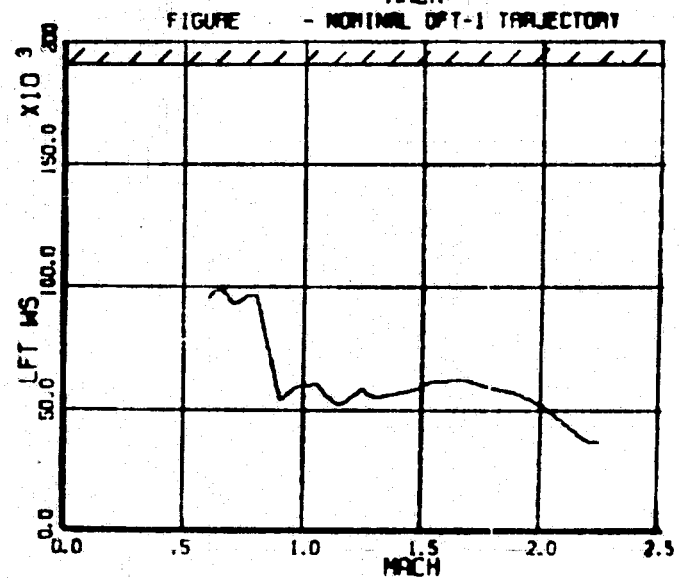
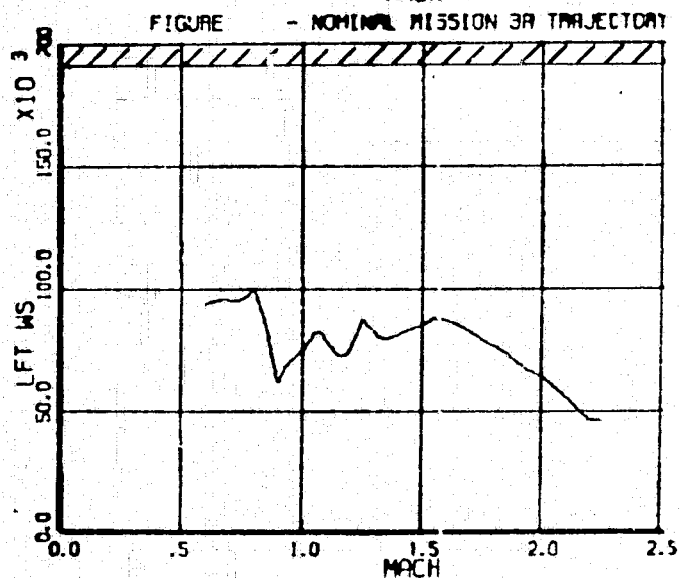
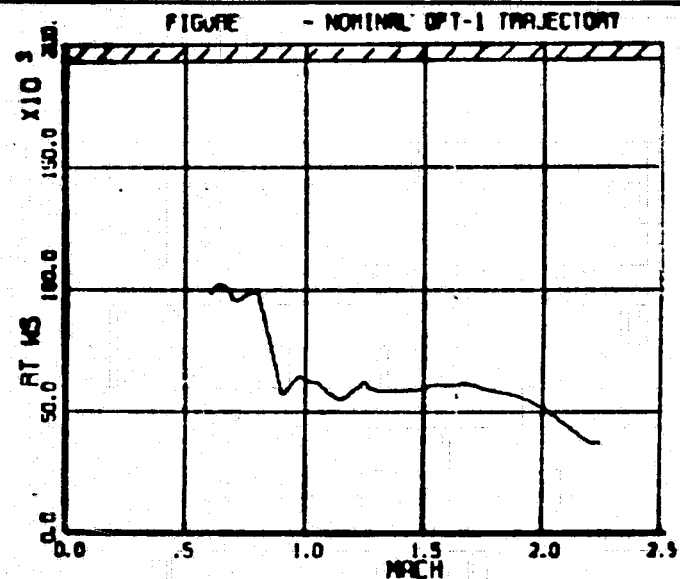
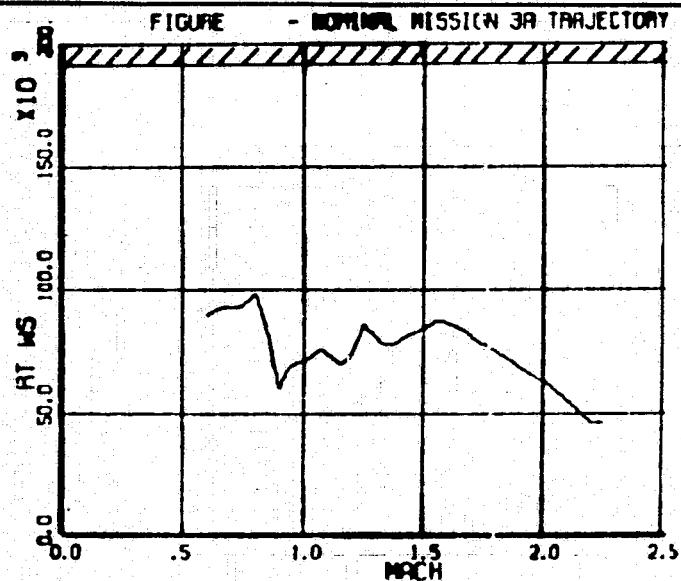


FIGURE 26.- NOMINAL INBOARD ELEVON HINGE MOMENT

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

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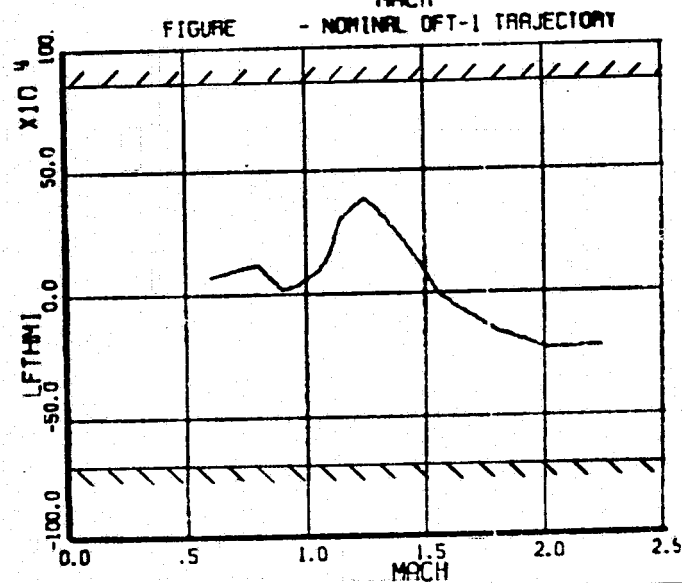
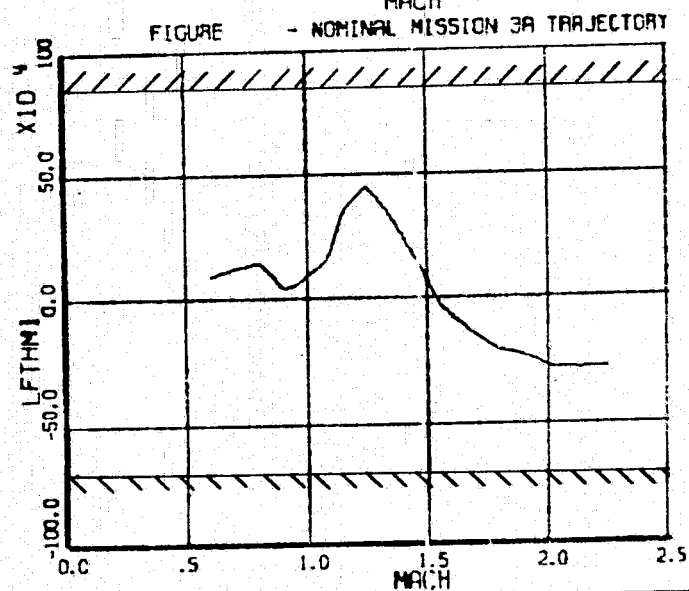
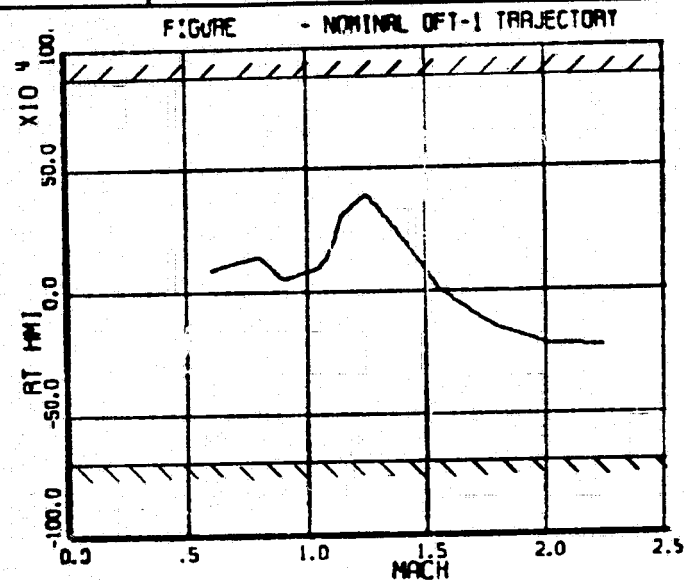
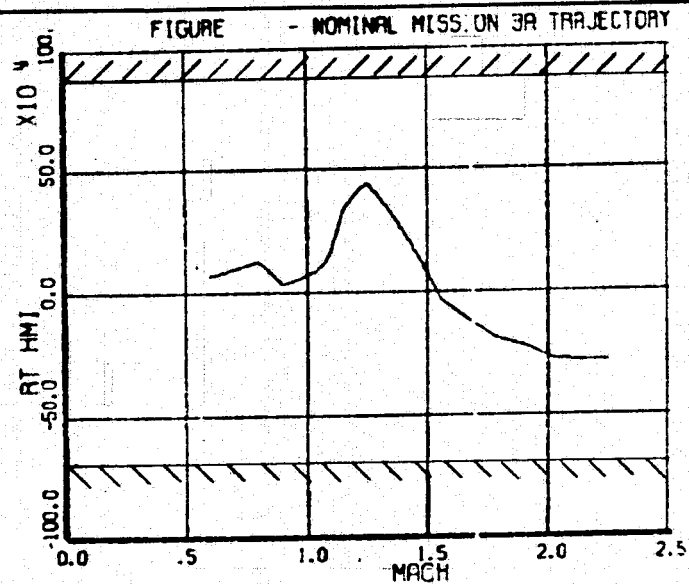


FIGURE 27.- NOMINAL OUTBOARD ELEVON HINGE MOMENT

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

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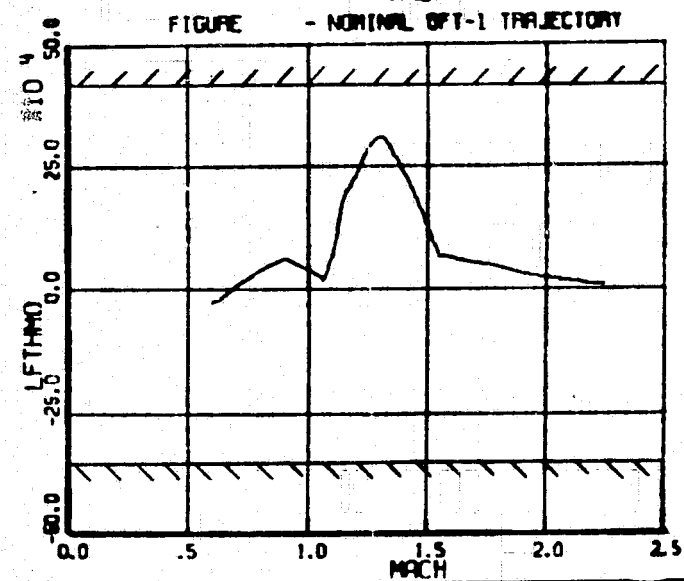
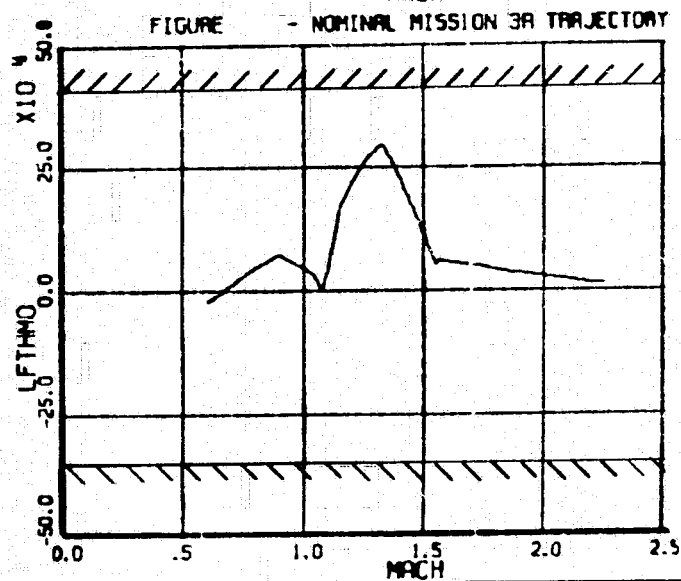
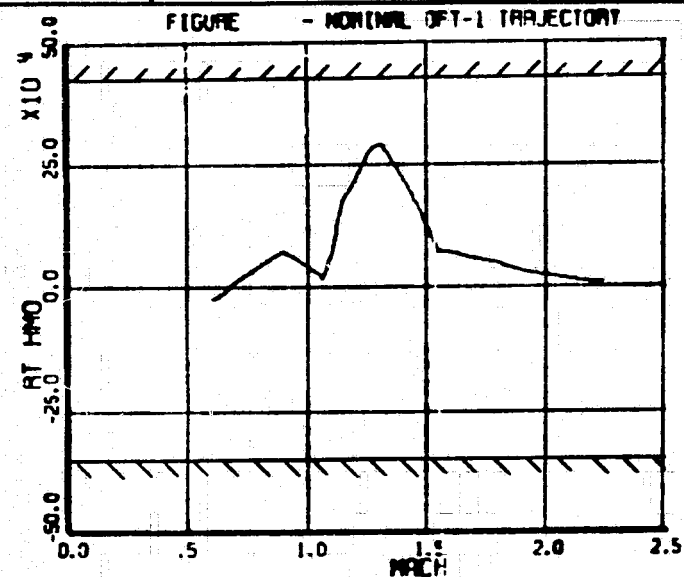
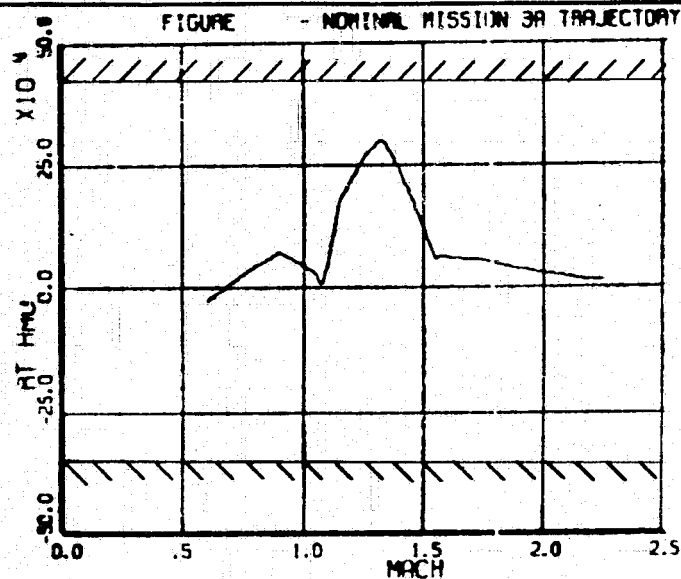


FIGURE 28.- NOMINAL FORWARD Z ATTACH LOAD INDICATOR

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE _____

BY L. Austin PLOT NO. _____

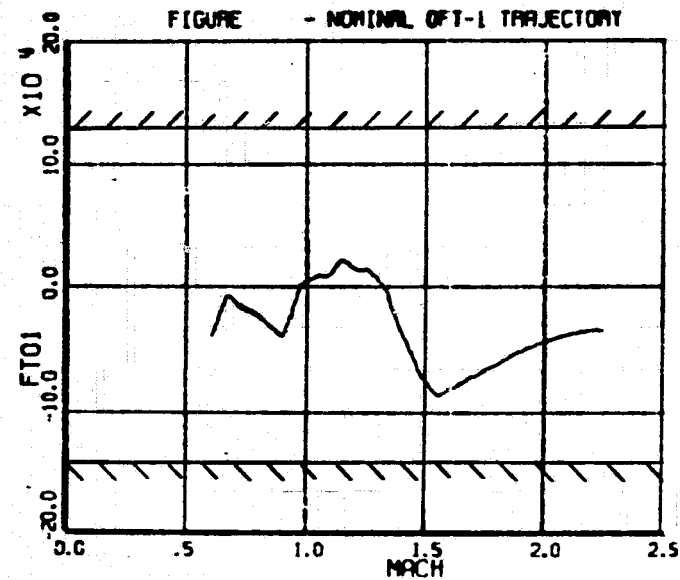
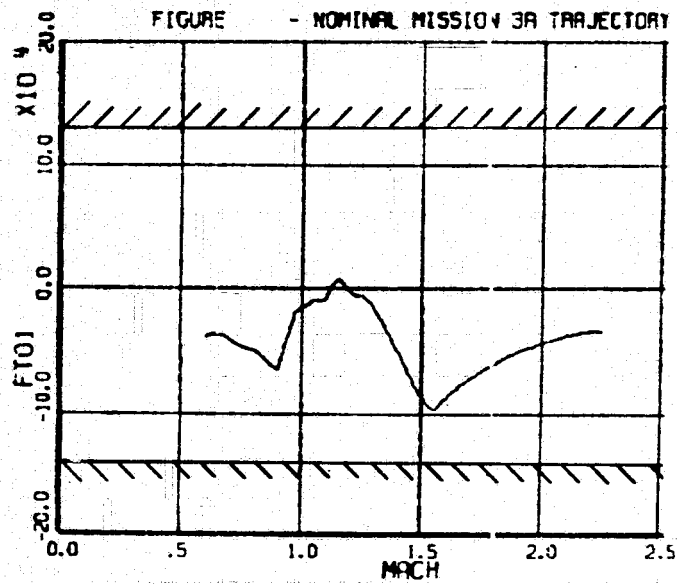


FIGURE 29.- NOMINAL FORWARD Y ATTACH LOAD INDICATOR

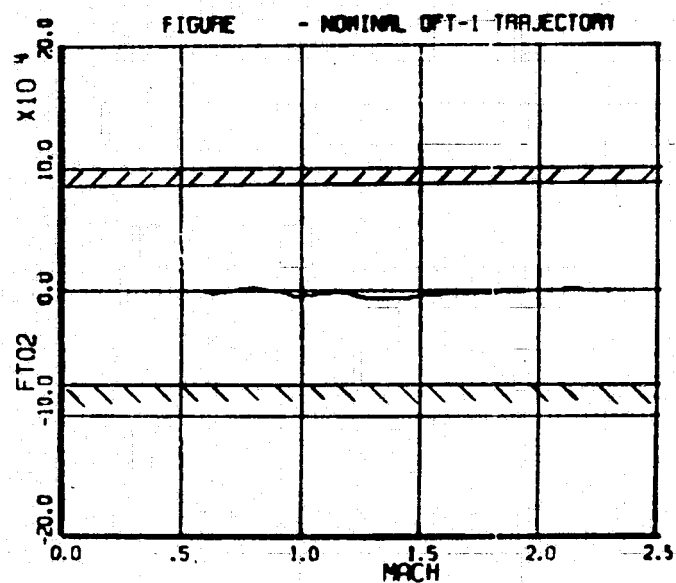
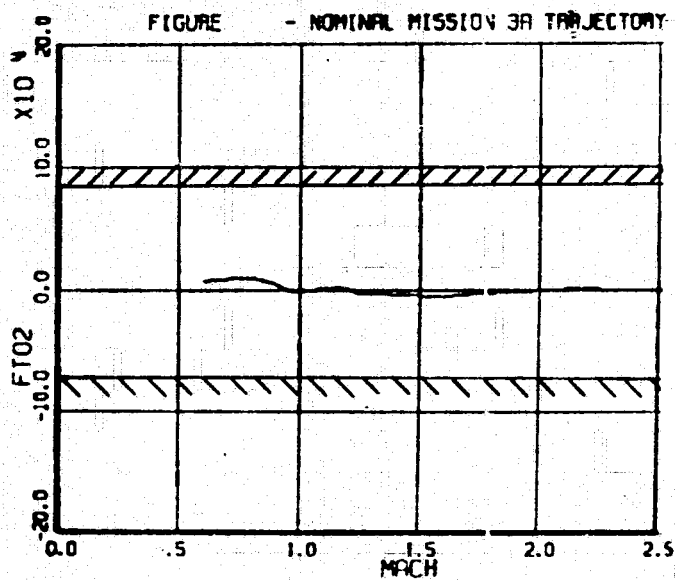
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FIGURE 3Q.- NOMINAL AFT LEFT Z ATTACH LOAD INDICATOR

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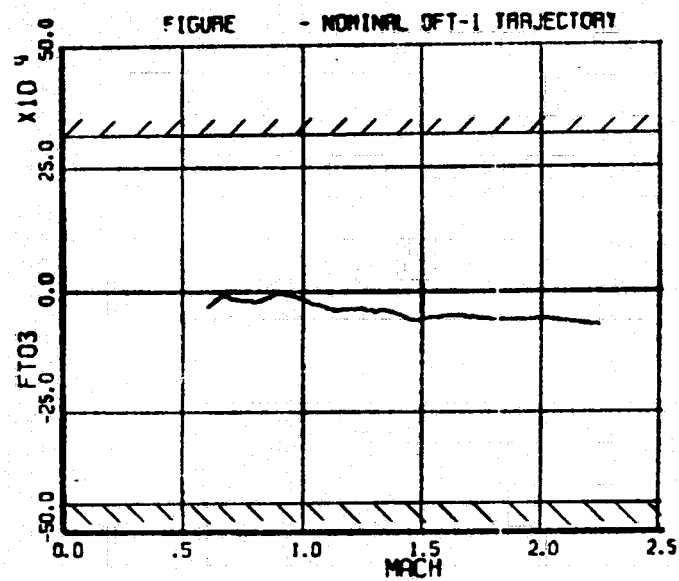
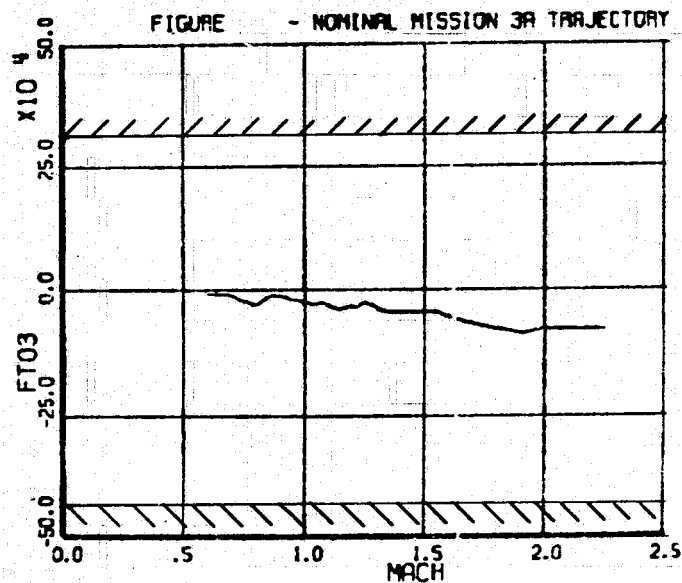


FIGURE 31.- NOMINAL AFT RIGHT Z ATTACH LOAD INDICATOR

ENGINEERING ANALYSIS DIVISION/EX

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BY L. Austin PLOT NO.

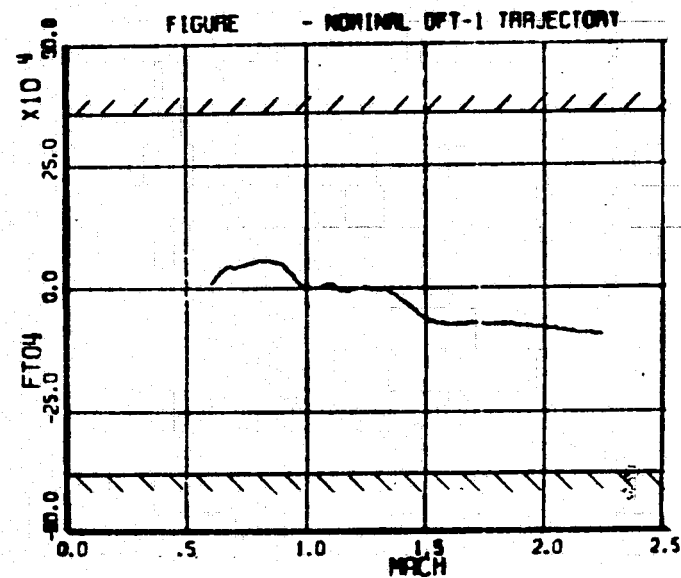
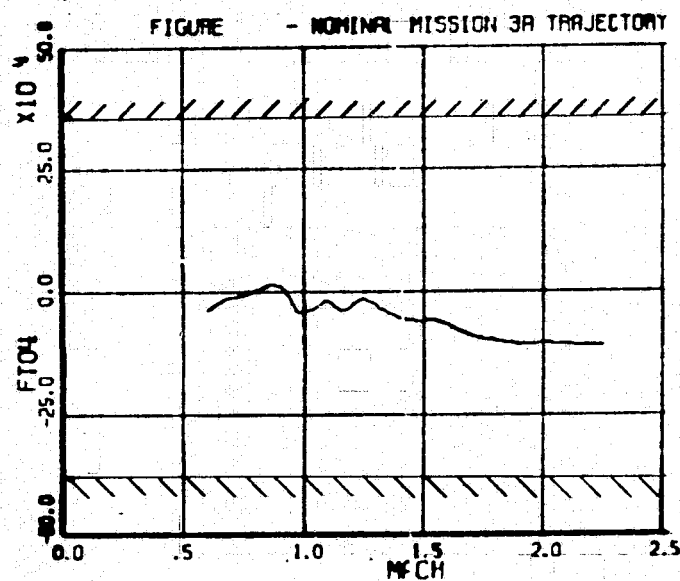


FIGURE 32.- NOMINAL AFT RIGHT Y ATTACH LOAD INDICATOR

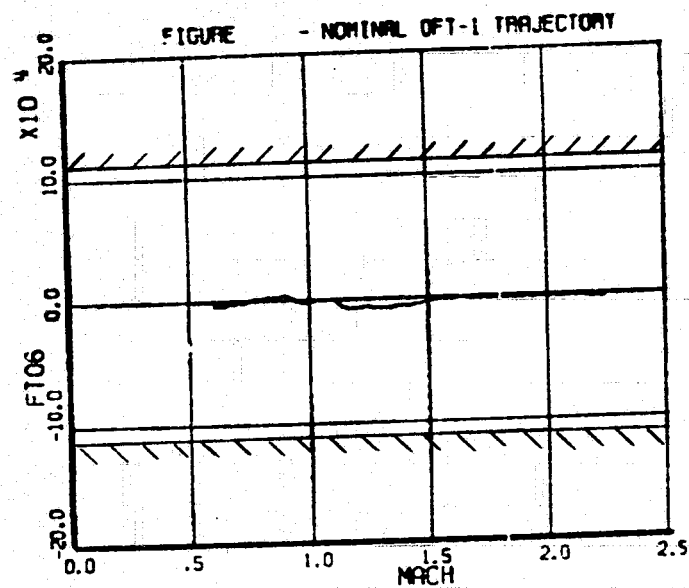
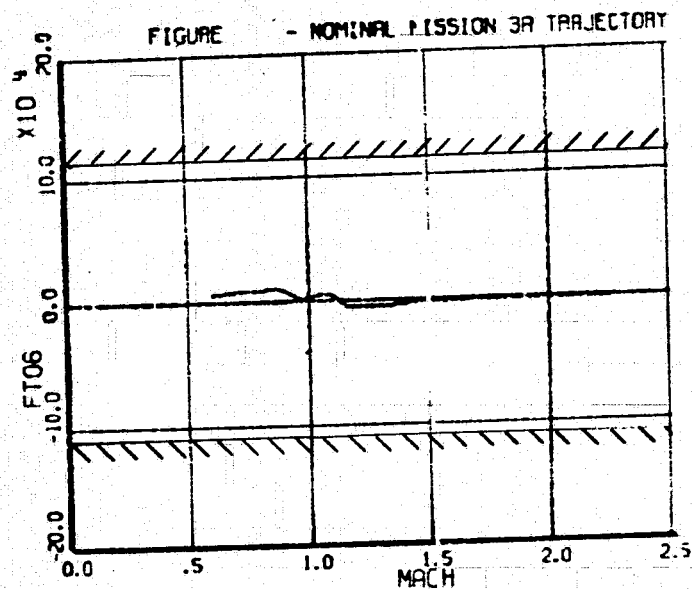
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FIGURE 33.- NOMINAL AFT LEFT X ATTACH LOAD INDICATOR

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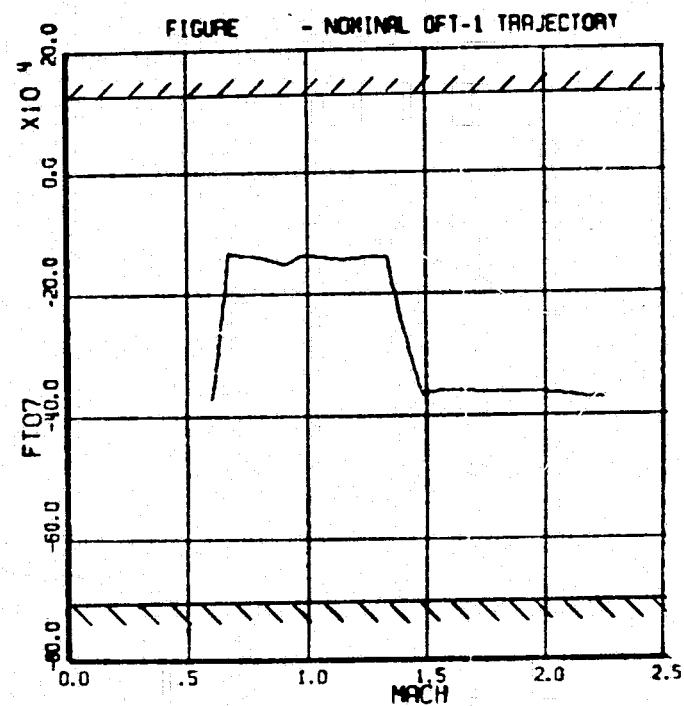
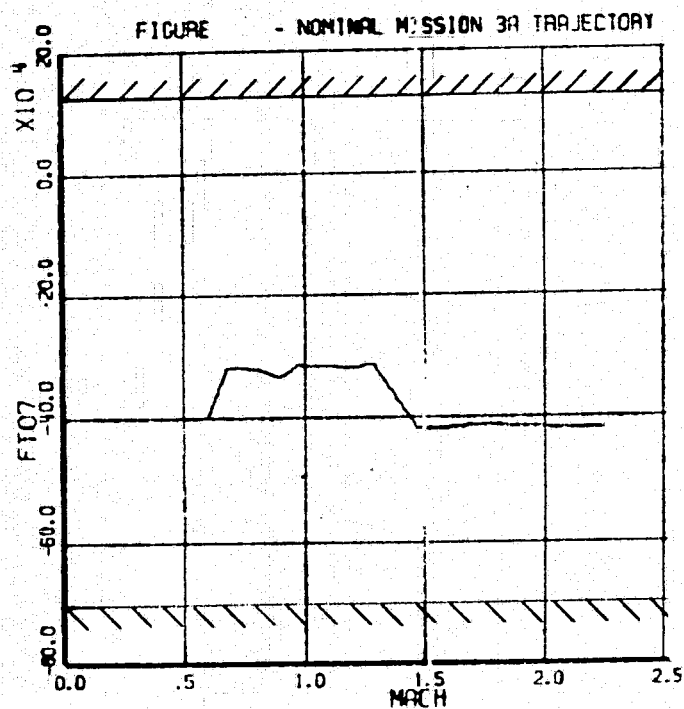


FIGURE 34.- NOMINAL AFT RIGHT X ATTACH LOAD INDICATOR

ENGINEERING ANALYSIS DIVISION/EX

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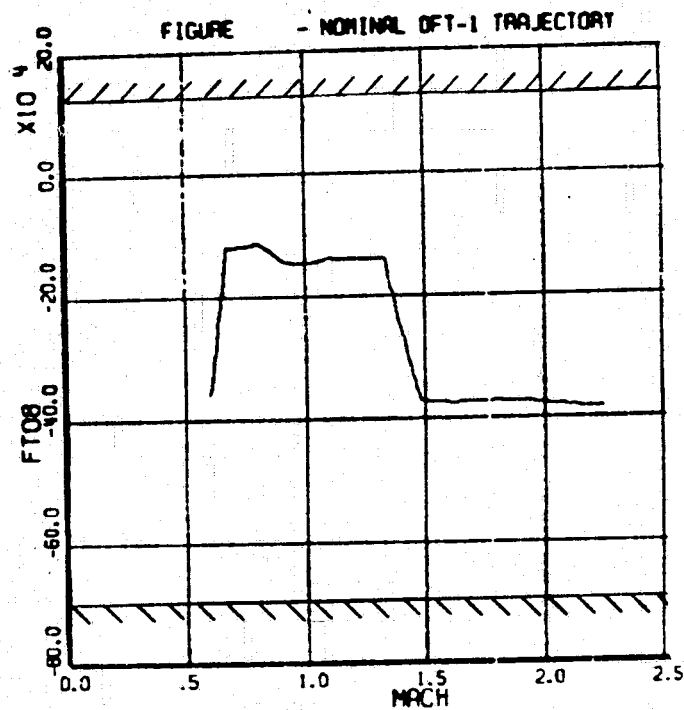
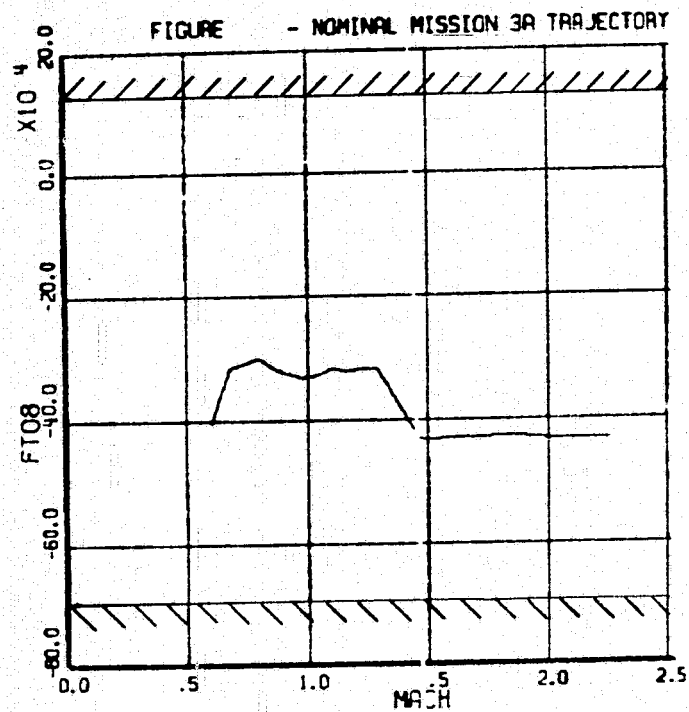


FIGURE 35.- NOMINAL FORWARD LEFT, RIGHT Z ATTACH LOAD INDICATORS

ENGINEERING ANALYSIS DIVISION/EX

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BY L. Austin

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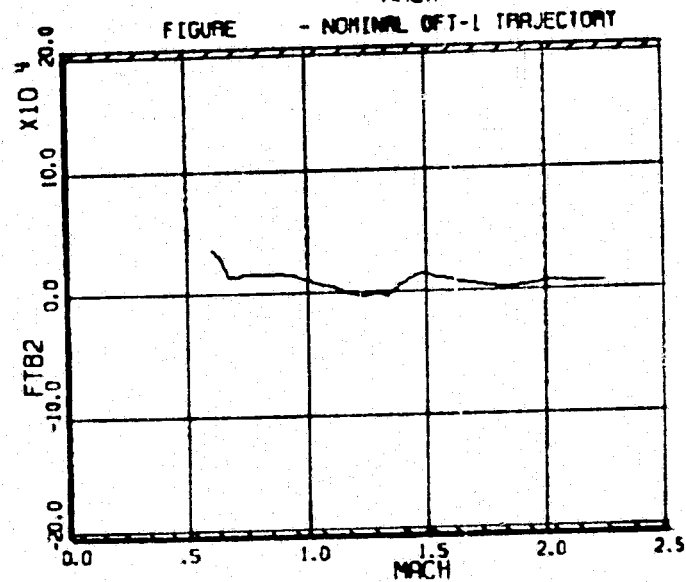
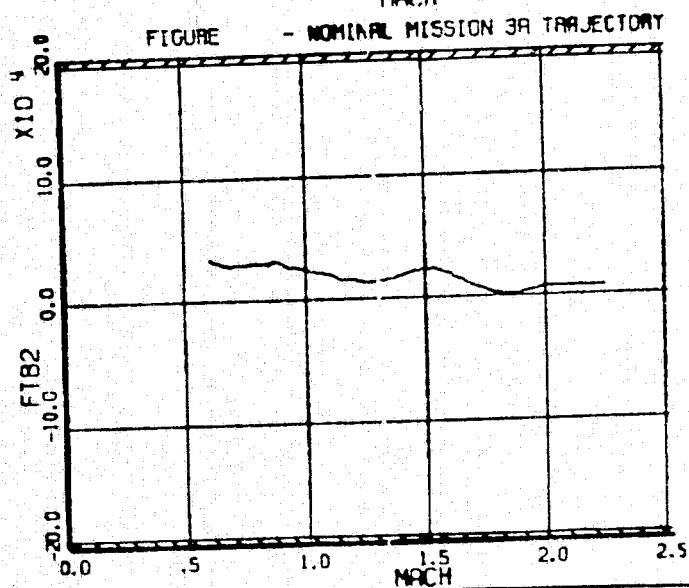
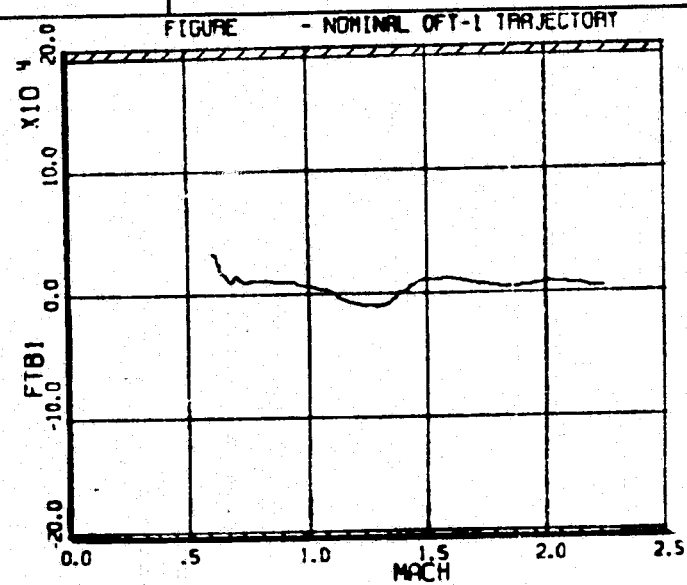
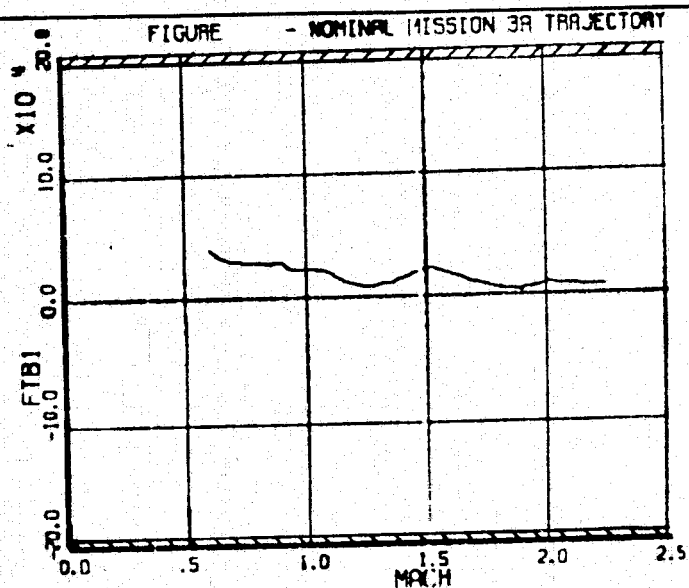


FIGURE 36.- NOMINAL FORWARD LEFT, RIGHT Y ATTACH LOAD INDICATORS

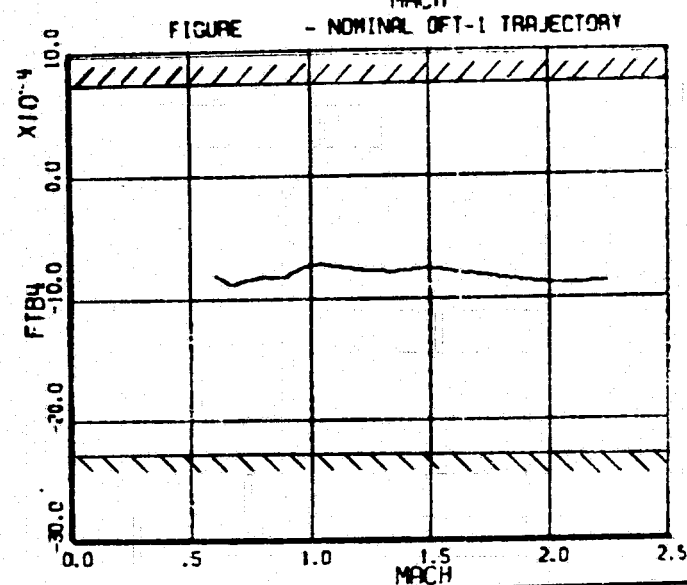
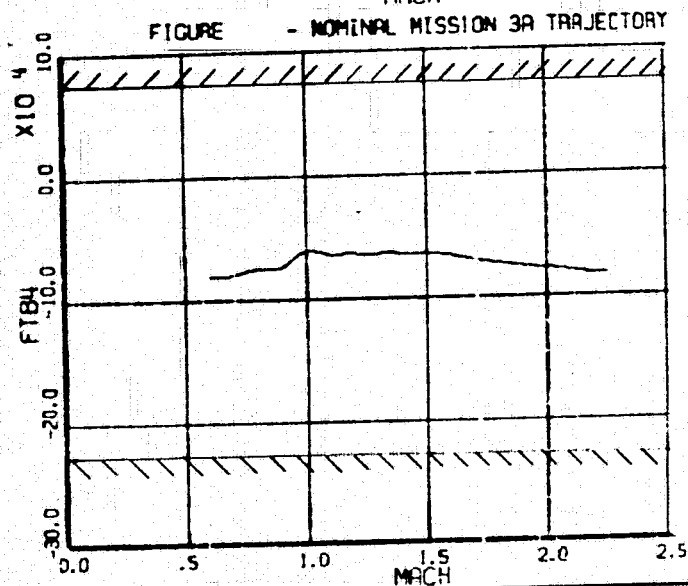
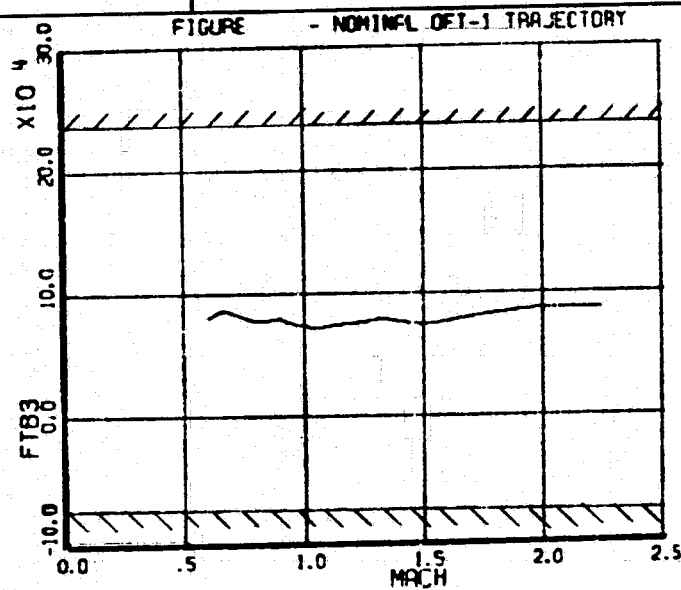
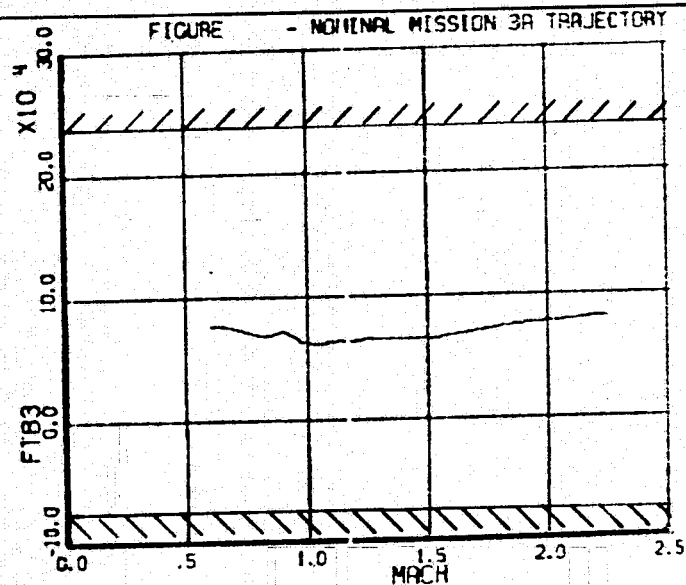
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FIGURE 37.- NOMINAL FORWARD LEFT, RIGHT X ATTACH LOAD INDICATORS

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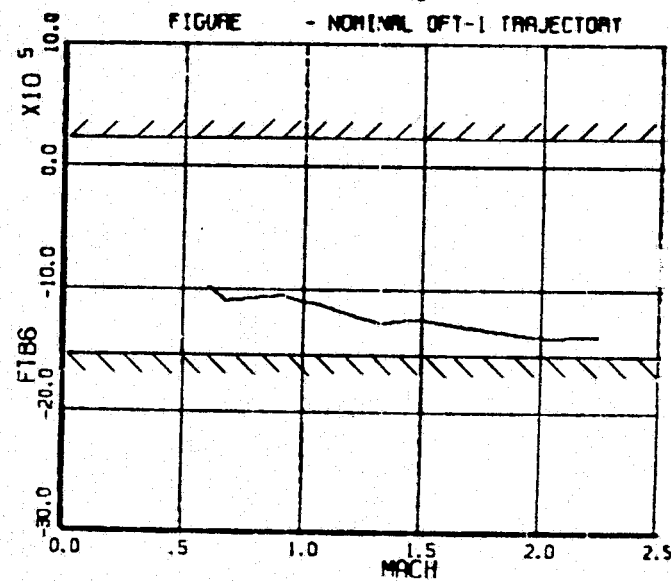
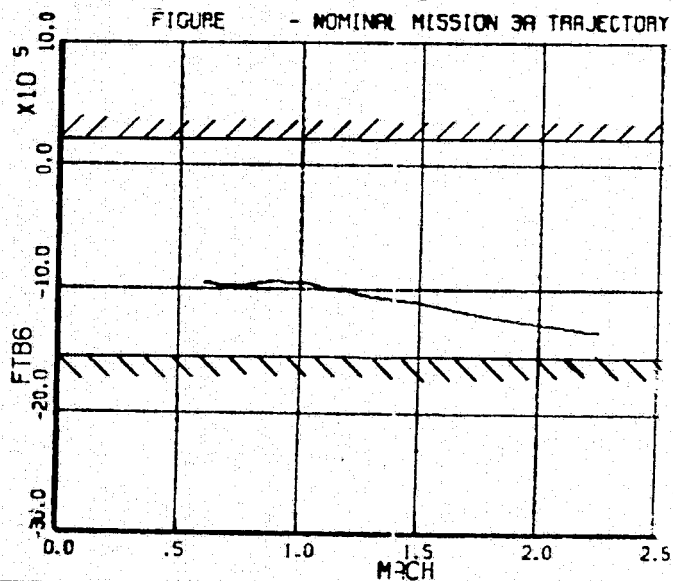
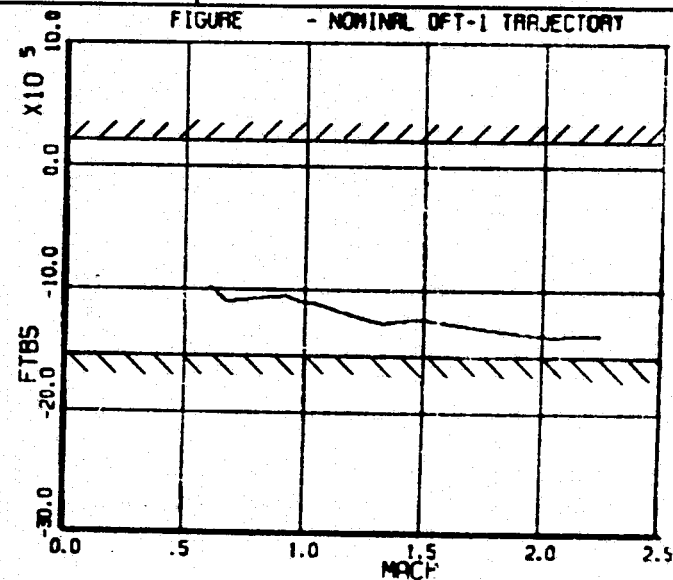
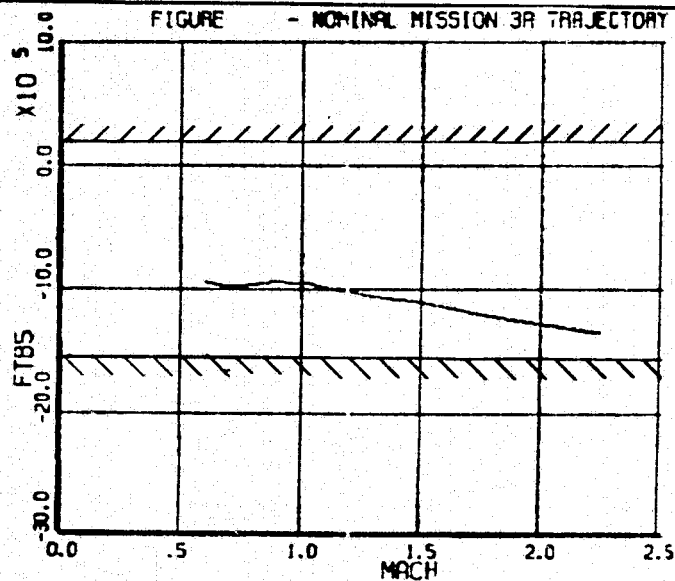


FIGURE 38.- NOMINAL AFT LEFT, RIGHT Z ATTACH LOAD INDICATORS

ENGINEERING ANALYSIS DIVISION/EX

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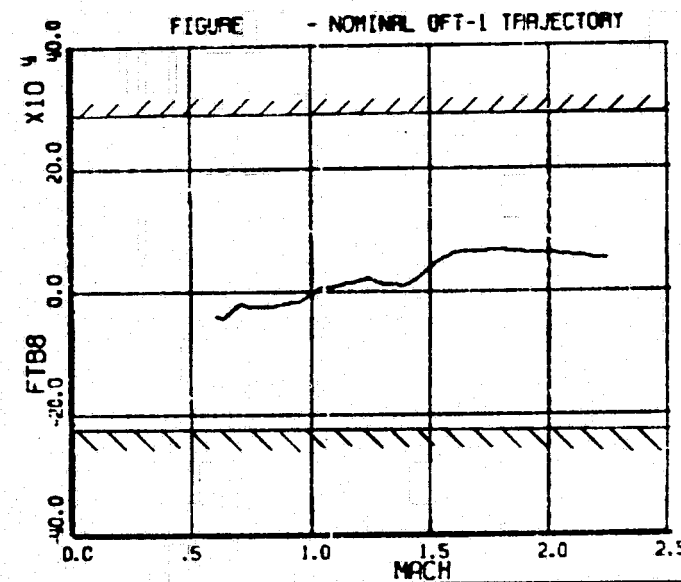
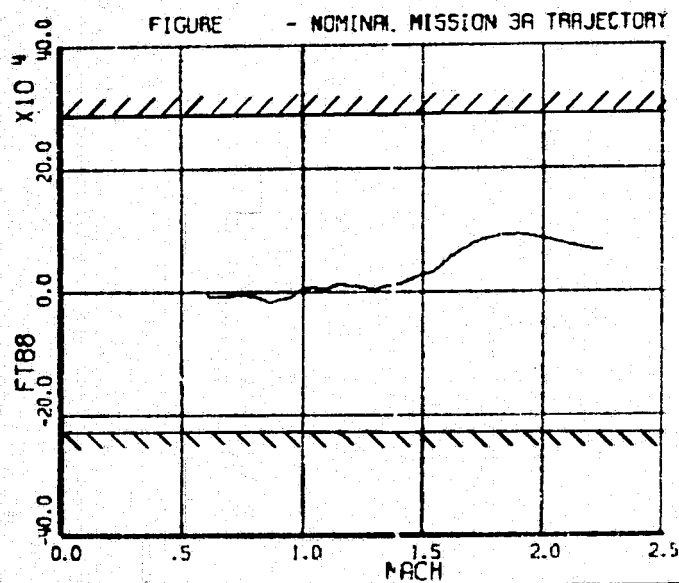
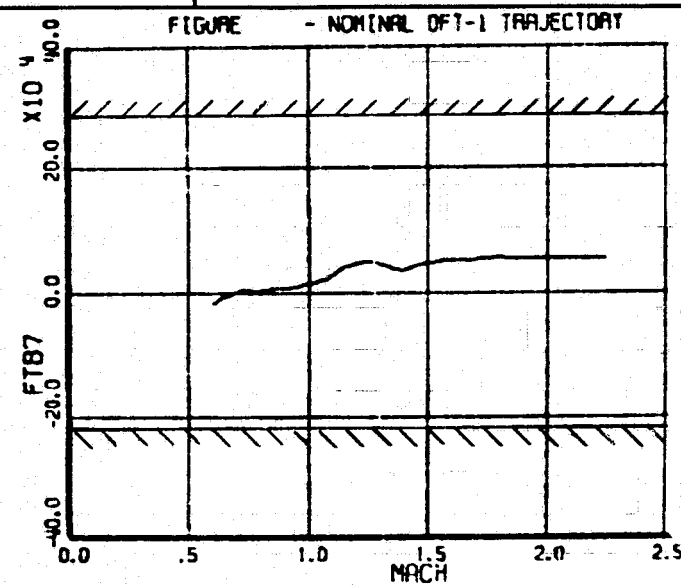
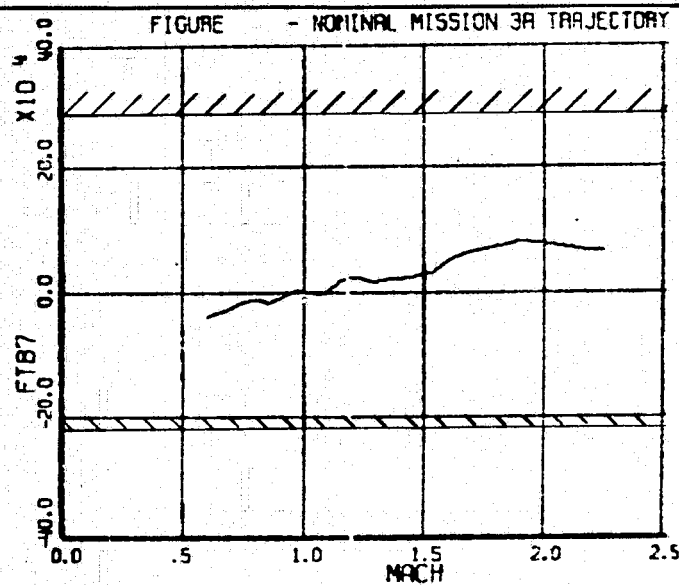


FIGURE 39.- NOMINAL AFT LEFT, RIGHT Y ATTACH LOAD INDICATORS

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

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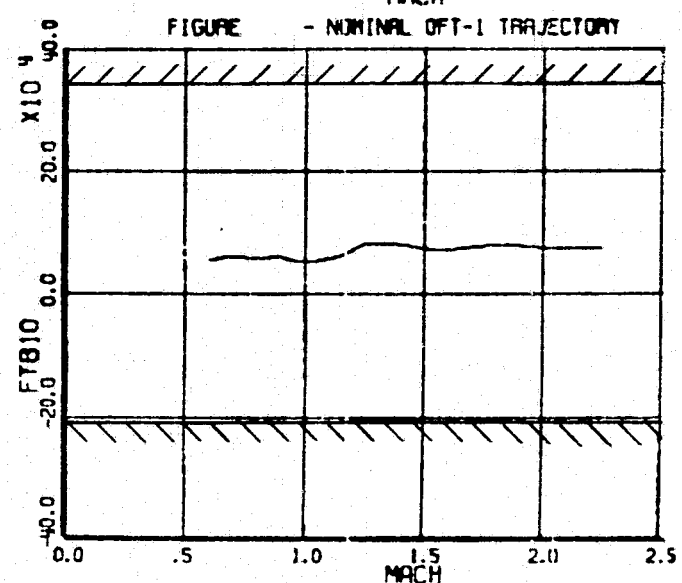
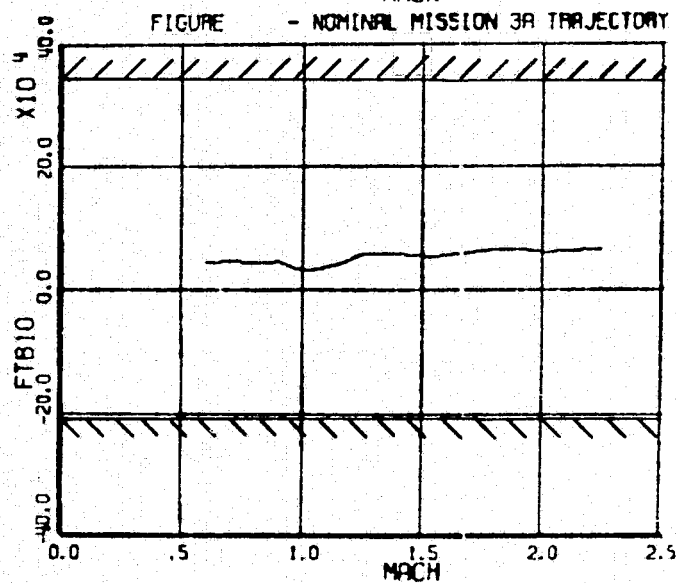
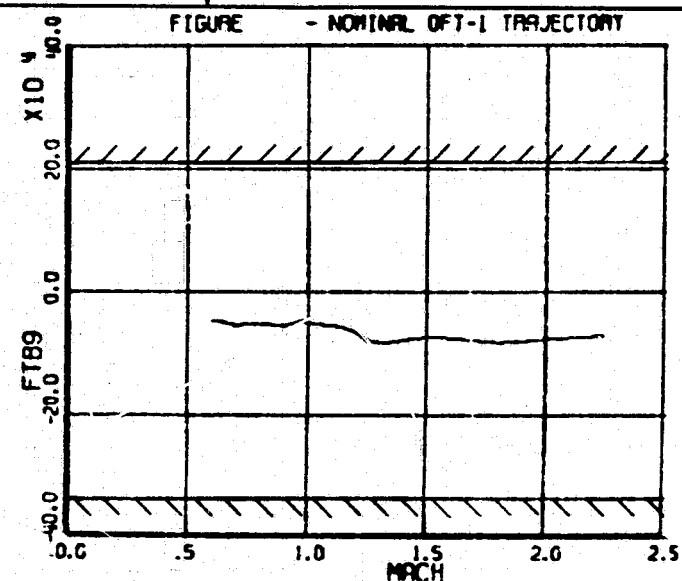
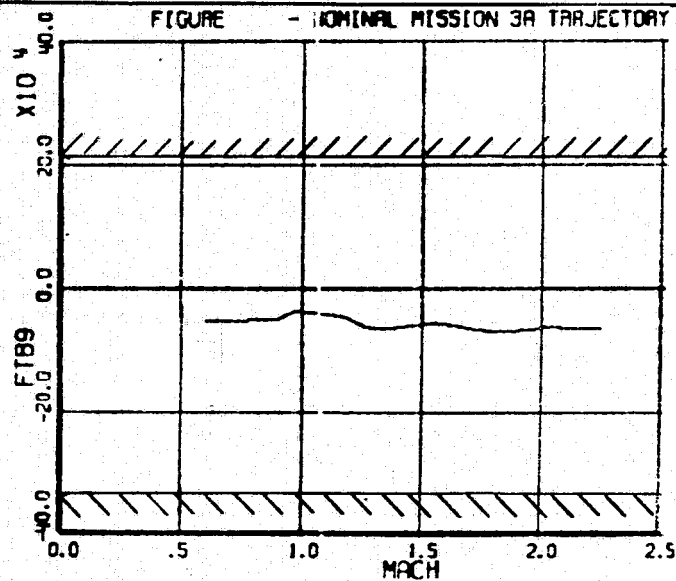


FIGURE 40.- NOMINAL LEFT, RIGHT SRB ATTACH MOMENTS

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

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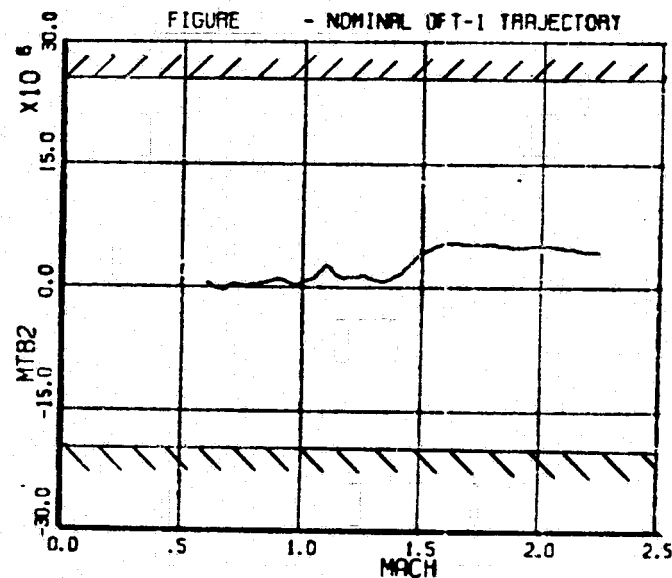
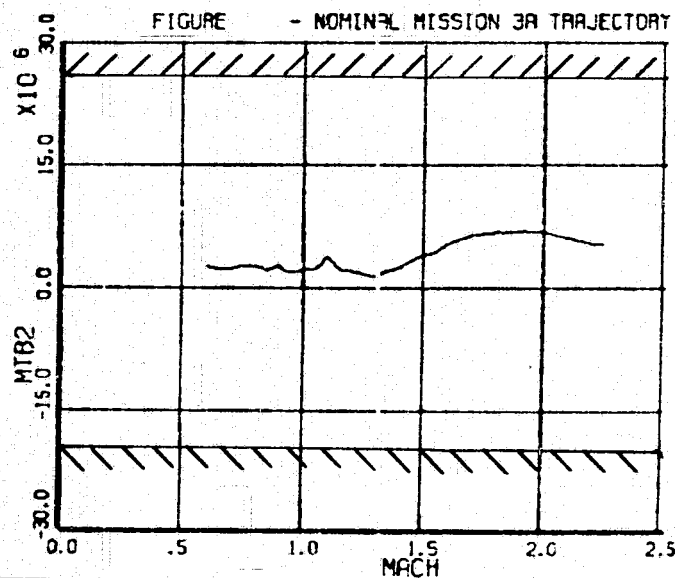
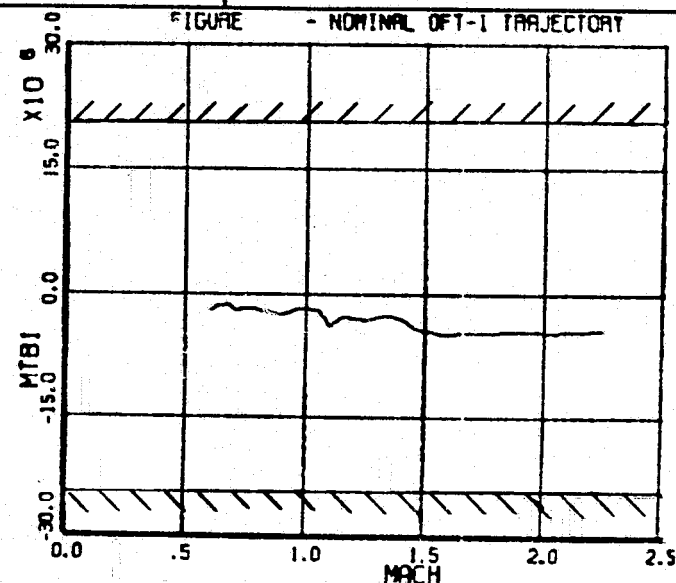
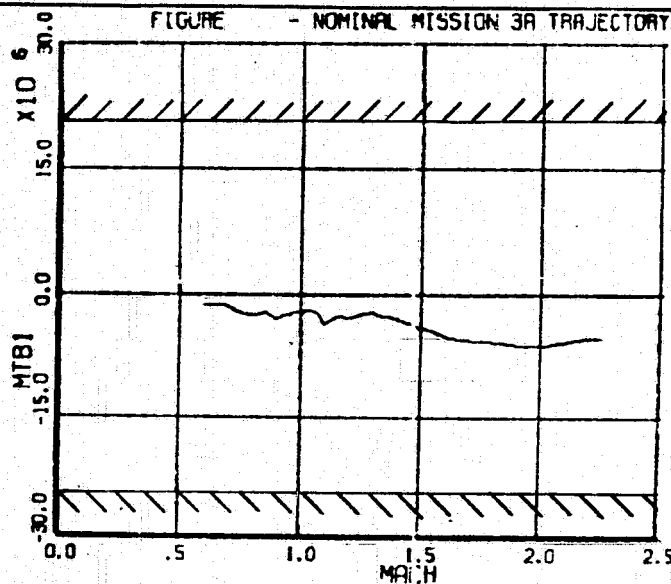


FIGURE 41.- NOMINAL OFT-1/MISSION 3A SUMMARY

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE _____

BY L. Austin PLOT NO. _____

● FIRST STAGE SSV INDICATORS SUMMARY

MISSION	MAXIMUM HEAT RATE, $\dot{q}$, BTU/FT ² /SEC	HEAT LOAD, q , BTU/FT ²	MAXIMUM HYDRAULIC SYSTEM FLOW, GPM	LOX BULKHEAD LOAD INDICATOR, LBS
3A	3.37	125.01	12	2,627,000
OFT-1	1.95	71.3	15	2,740,000

FIGURE 42.- NOMINAL SRB STAGING CONDITIONS

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PARAMETER	MISSION	
	3A	OFT-1
Q, LB/FT ²	38	23
V _R , FT/SEC	4623	3978
γ _R , DEG	27.8	39.3
h, FT	151,318	155,521
α, DEG	1.13	1.92
β, DEG	0.04	0.11
φ, DEG	180	180
p, DEG/SEC	0.14	0.01
q, DEG/SEC	0.19	0.07
r, DEG/SEC	-0.09	0.01

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FIGURE 43.- MINIMUM LOAD INDICATOR MARGINS (%)

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LOAD INDICATOR

NOMINAL 3A

NOMINAL OFT-1

WRB	67	64
WS	47	46
HMO	28	26
HMI	54	60
FT01	35	43
FT02	91	91
FT03	83	81
FT04	77	79
FT06	91	94
FT07	71	62
FT08	68	57
FTB1,2	78	80
FTB3,4	91	91
FTB5,6	30	24
FTB7,8	73	72
FTB9,10	86	91
MTB1,2	79	86

NOTE: $0.6 \leq \text{MACH NUMBER} \leq 2.2$

FIGURE 44.- NOMINAL FLUTTER MARGIN

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE _____

BY L. Austin PLOT NO. _____

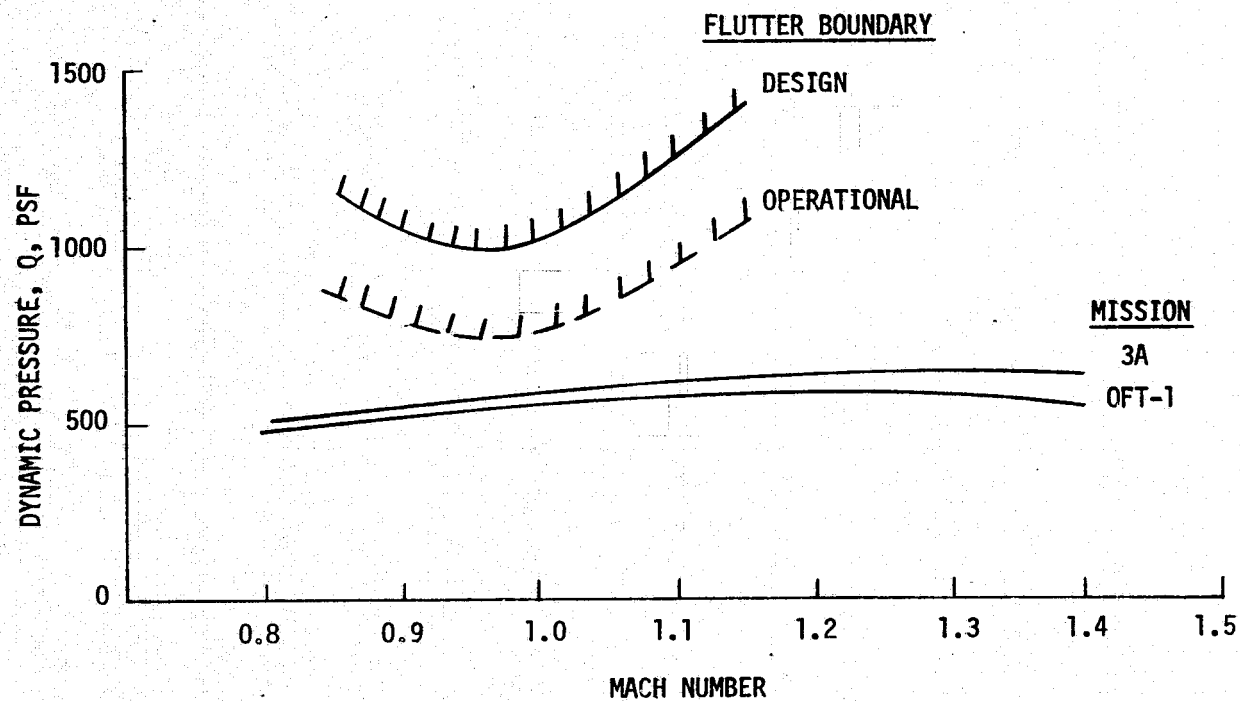


FIGURE 45.- OFT-1,3A SQUATCHELOIDS/MACH = 1.05

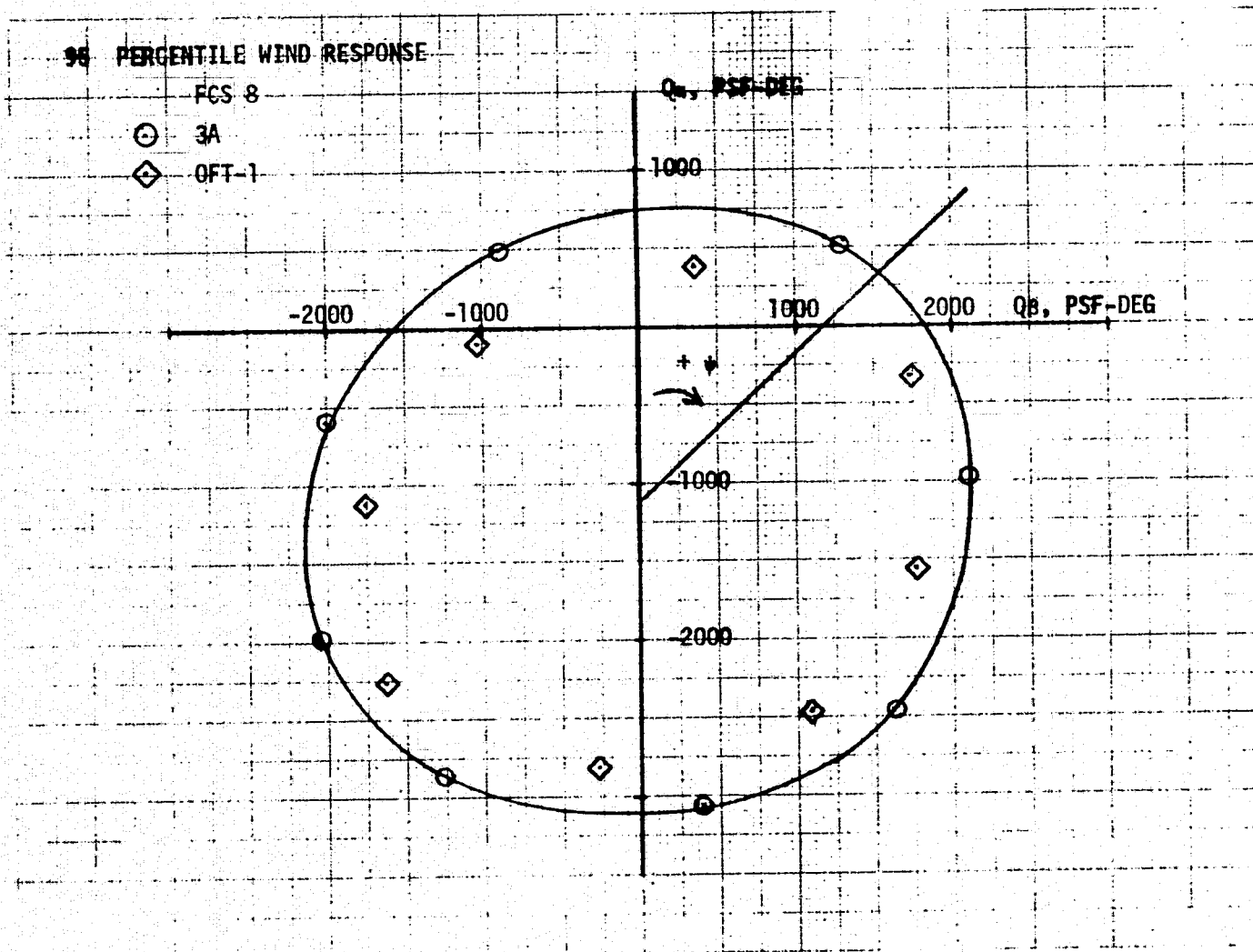
ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

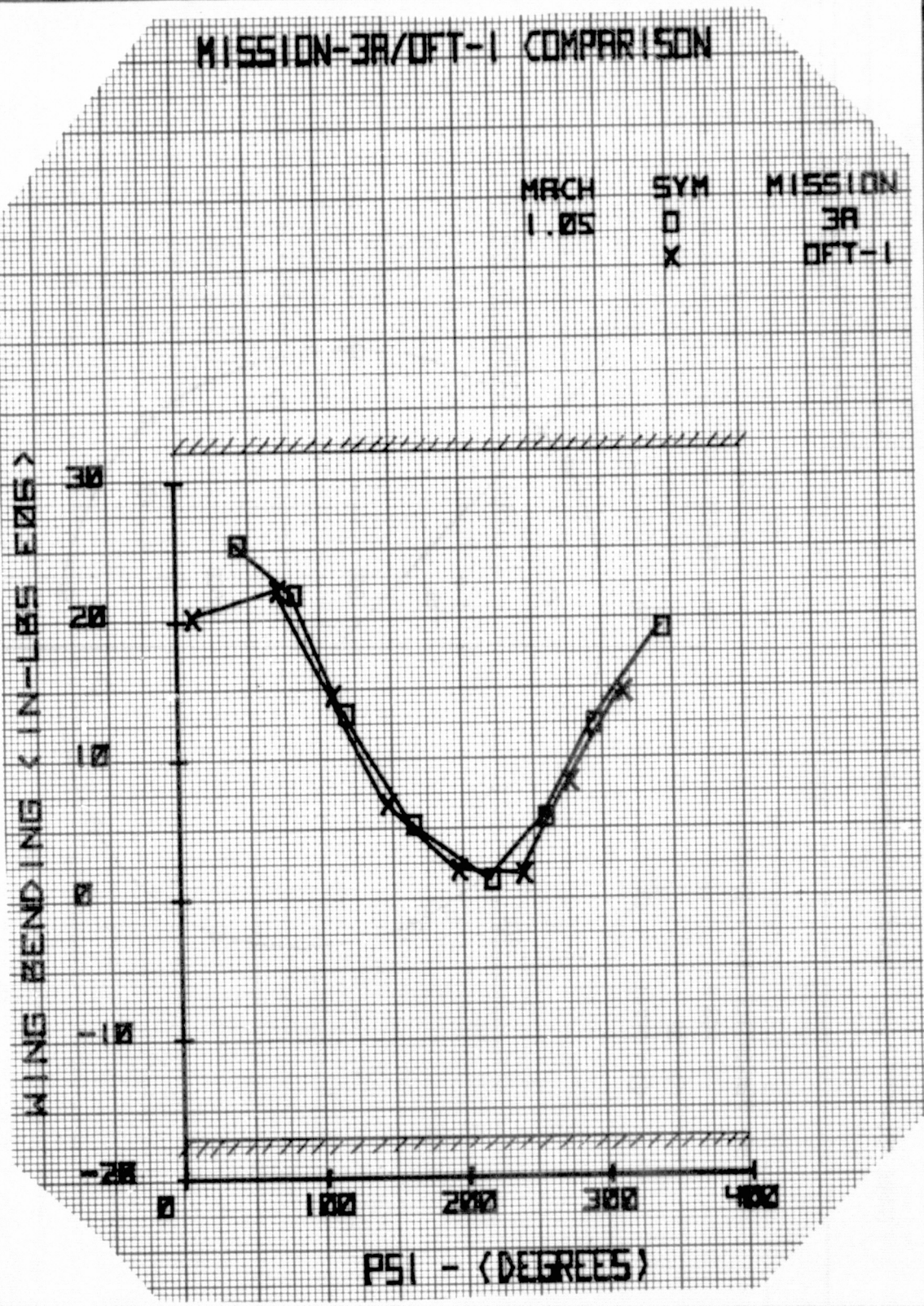
BY L. Austin

PLOT NO.



ENGINEERING ANALYSIS DIVISION/EX
 BRANCH EX42 DATE
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FIGURE 46.- SENSITIVITY OF RIGHT WING BENDING TO VARIATIONS
 IN WIND DIRECTION



NASA-JSC

JSC FORM 1138 (MAR 73)

FIGURE 47.- SENSITIVITY OF LEFT WING BENDING TO VARIATIONS IN WIND DIRECTION

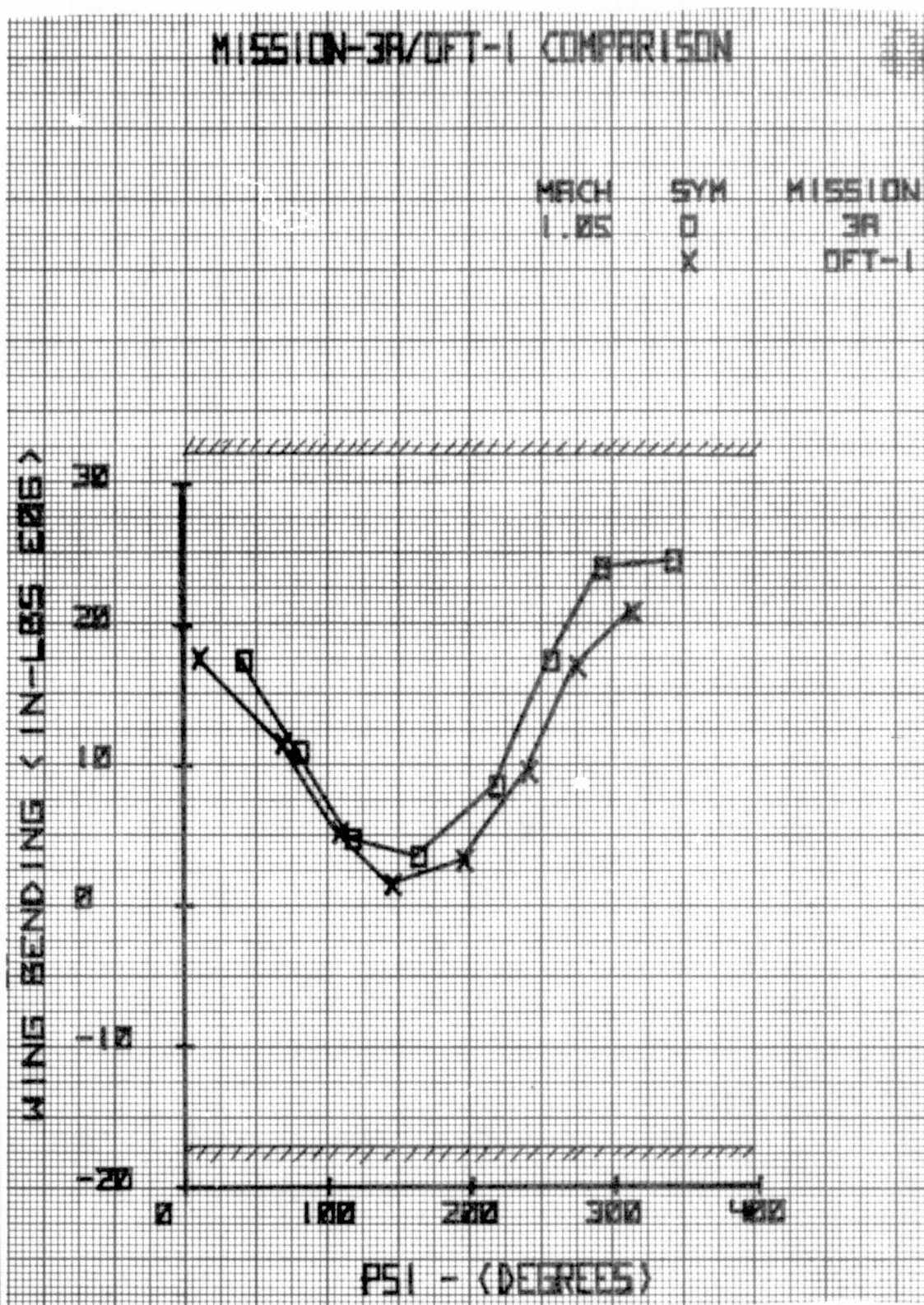
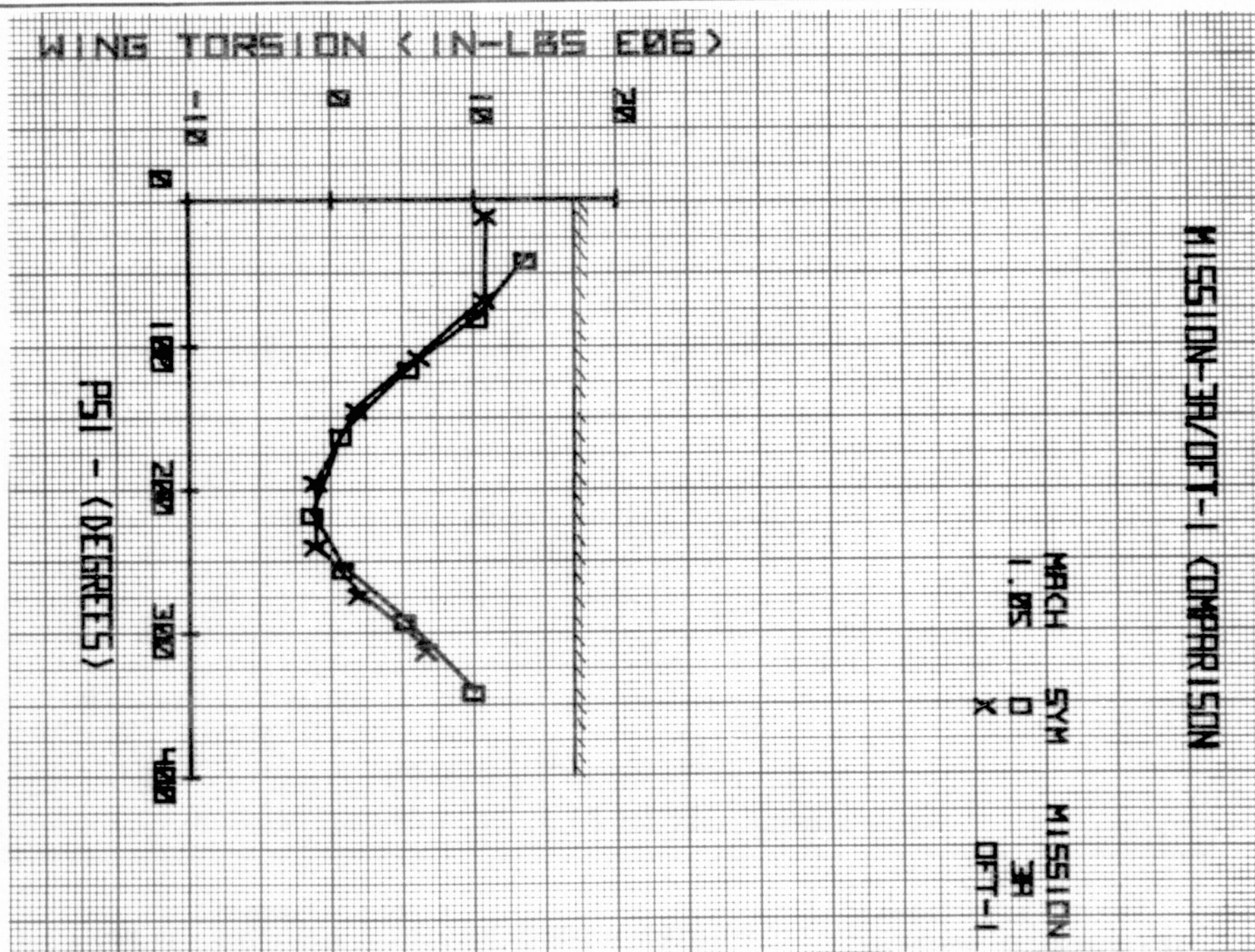


FIGURE 48.- SENSITIVITY OF RIGHT WING TORSION TO VARIATIONS IN WIND DIRECTIONS

ENGINEERING ANALYSIS DIVISION/EX
BRANCH EX42 DATE _____
BY L. Austin PLOT NO. _____



ORIGINAL PAGE NO

NASA-JSC

FIGURE 49.- SENSITIVITY OF LEFT WING TORSION TO VARIATIONS
IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX
BRANCH EX42 DATE
BY L. Austin PLOT NO.

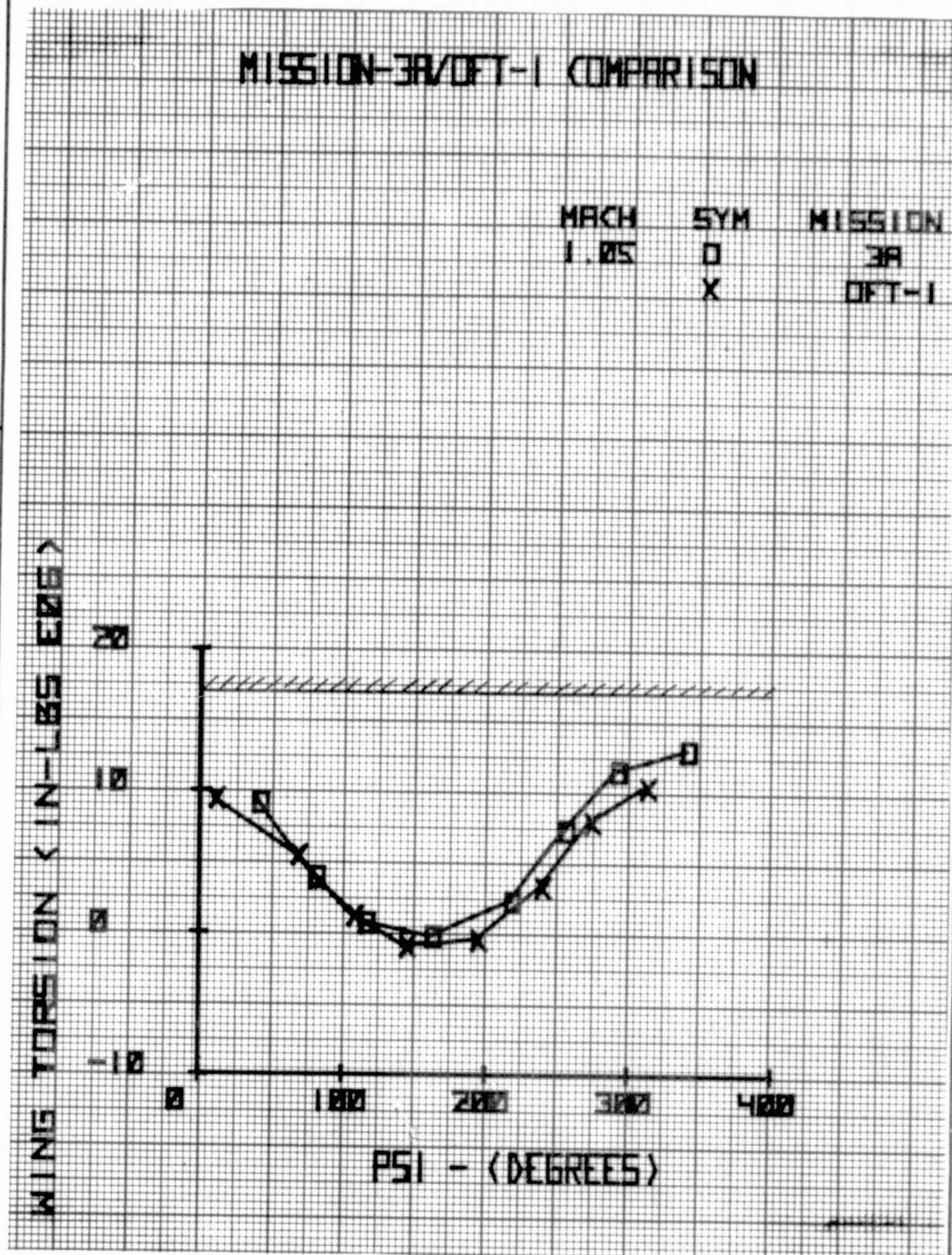
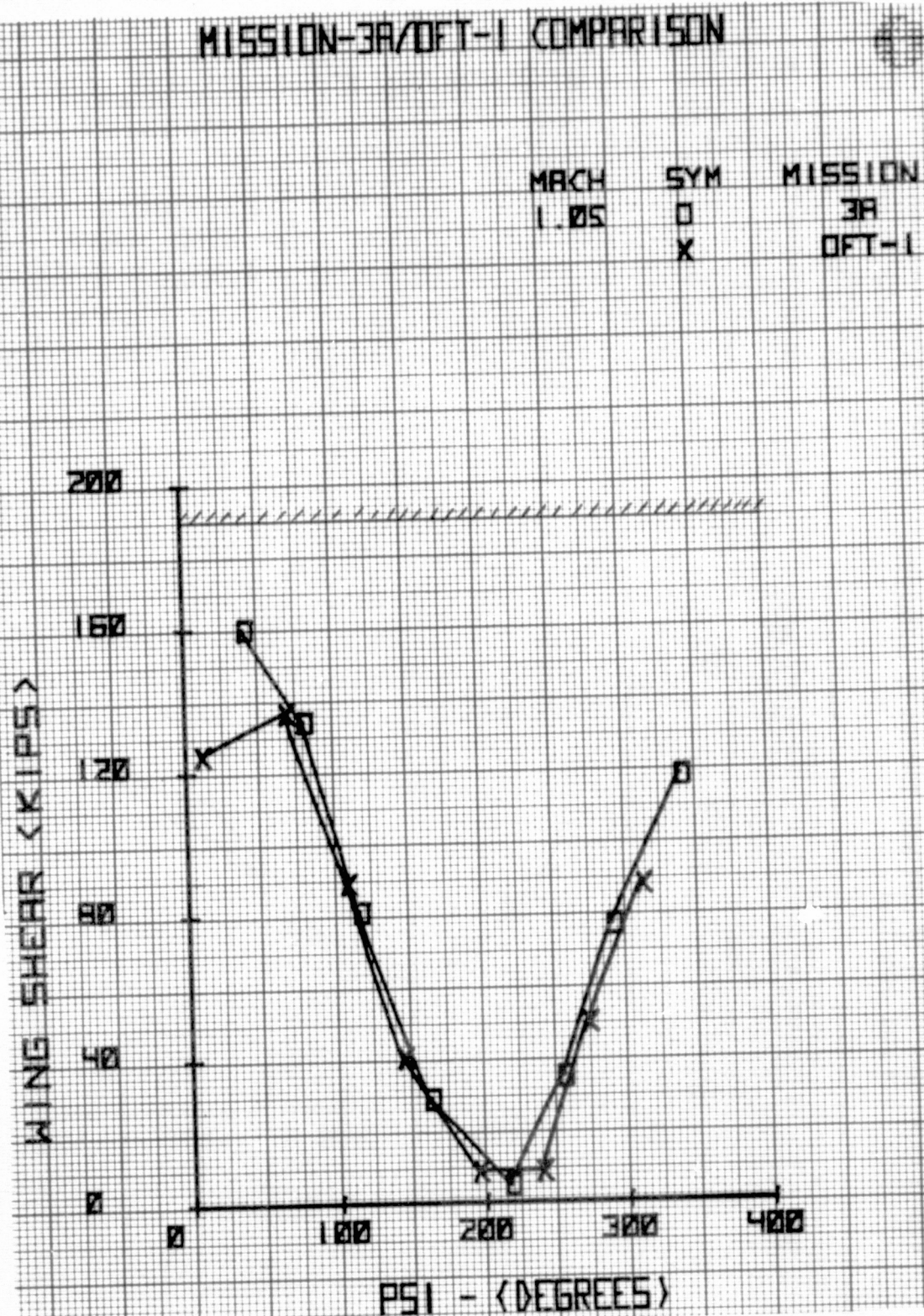
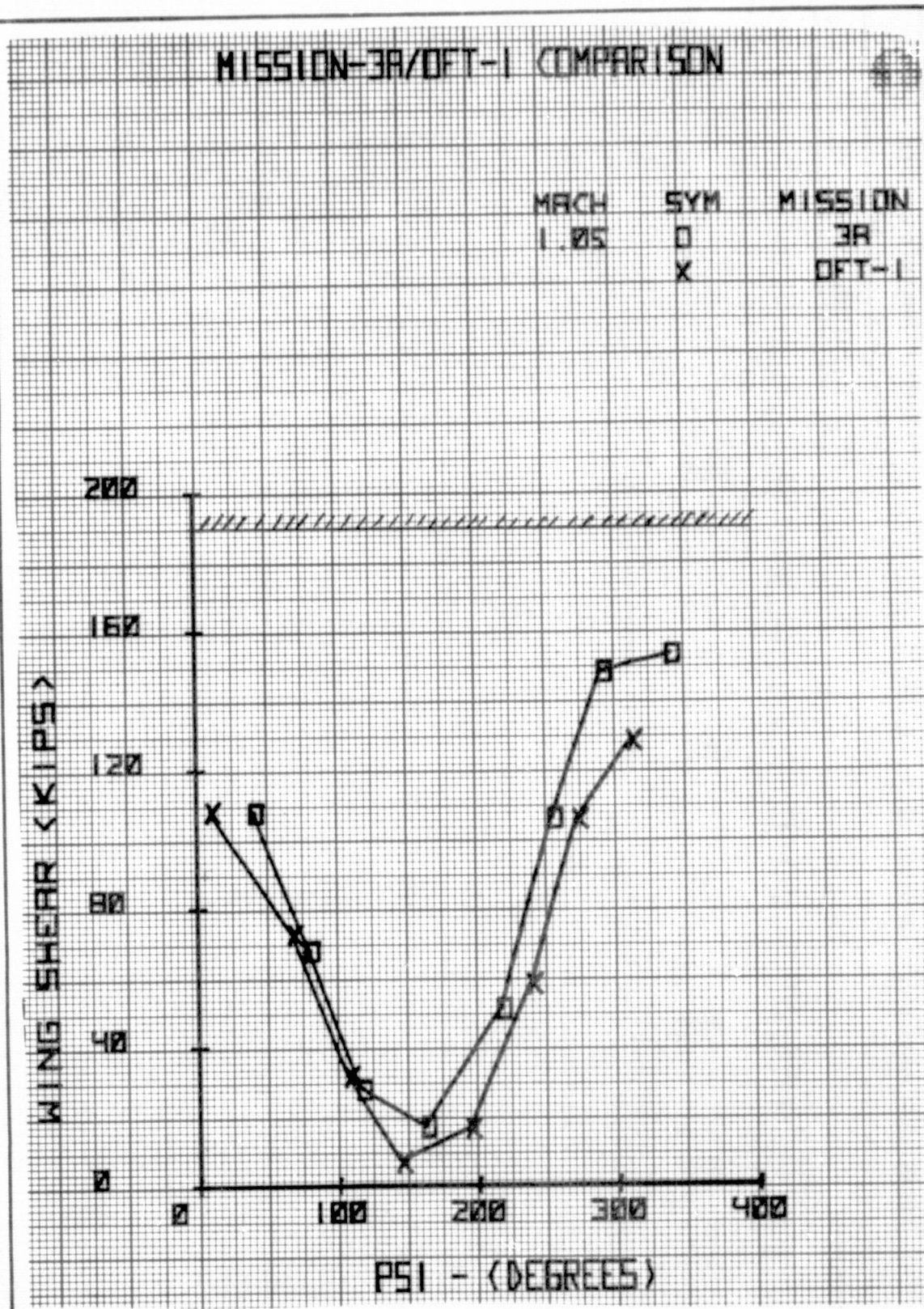


FIGURE 50.- SENSITIVITY OF RIGHT WING SHEAR TO VARIATIONS IN WIND DIRECTION



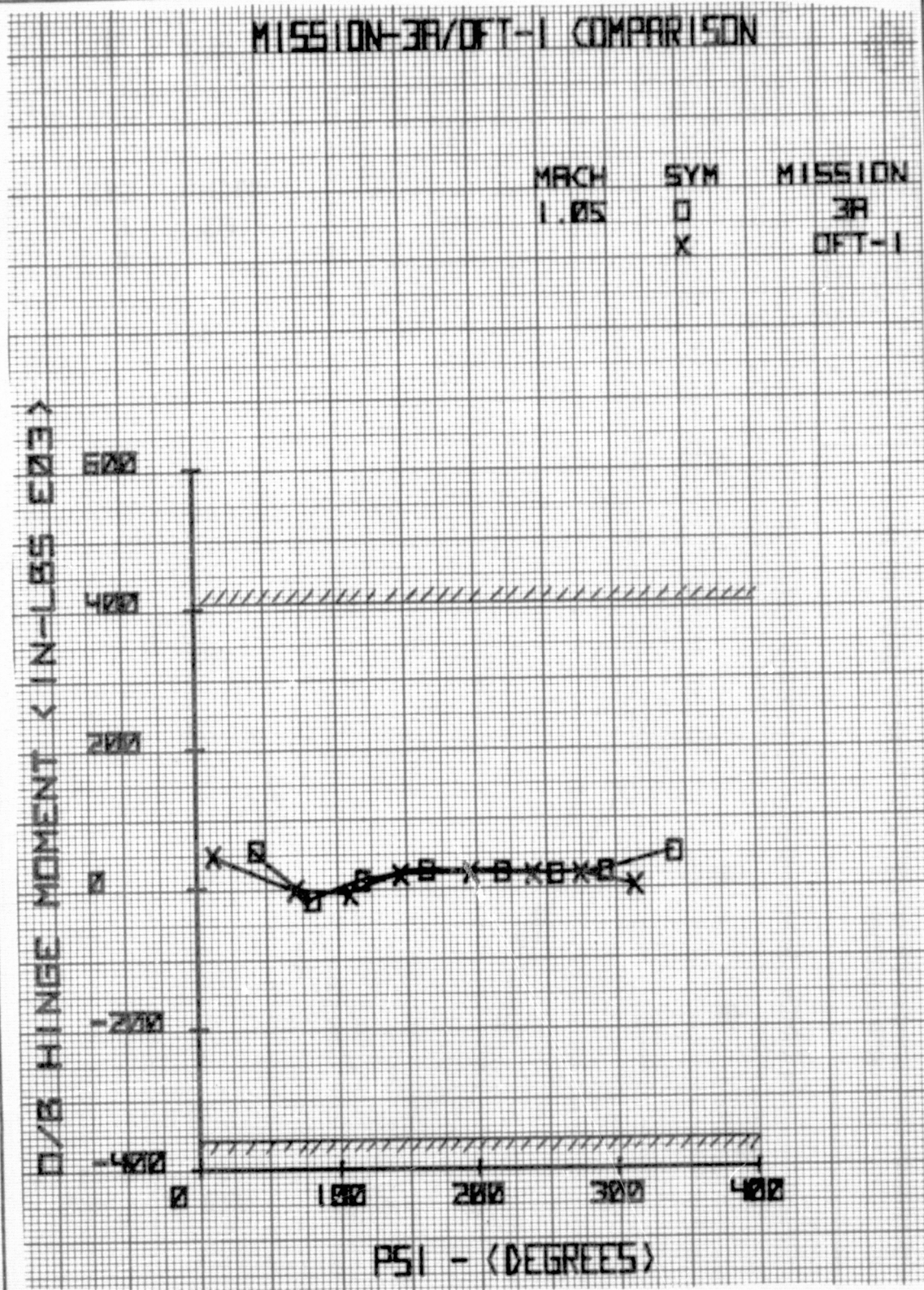
ENGINEERING ANALYSIS DIVISION/EX
 BRANCH EX42 DATE
 BY L. Austin PLOT NO.

FIGURE 51.- SENSITIVITY OF LEFT WING SHEAR TO VARIATIONS IN WIND DIRECTION



ENGINEERING ANALYSIS DIVISION/EX
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 BY L. Austin PLOT NO.

FIGURE 52.- SENSITIVITY OF RIGHT HMO TO VARIATIONS IN WIND DIRECTION



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JSC FORM 1138 (MAR 73)

FIGURE 53.- SENSITIVITY OF LEFT HMO TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE _____

BY L. Austin

PLOT NO. _____

MISSION-3R/DFT-1 COMPARISON

WIND
1.05

SYM
D

MISSION
3R
DFT-1

D/B HINGE MOMENT (IN-LBS FT³)

PSI - (DEGREES)

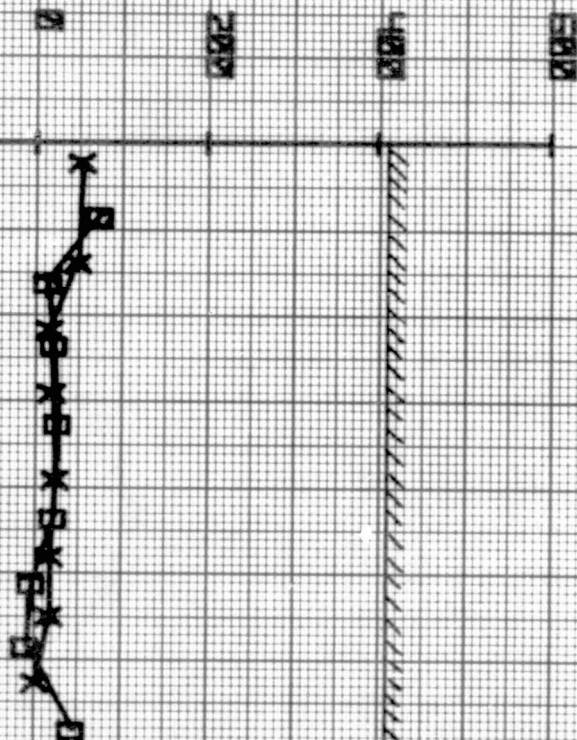
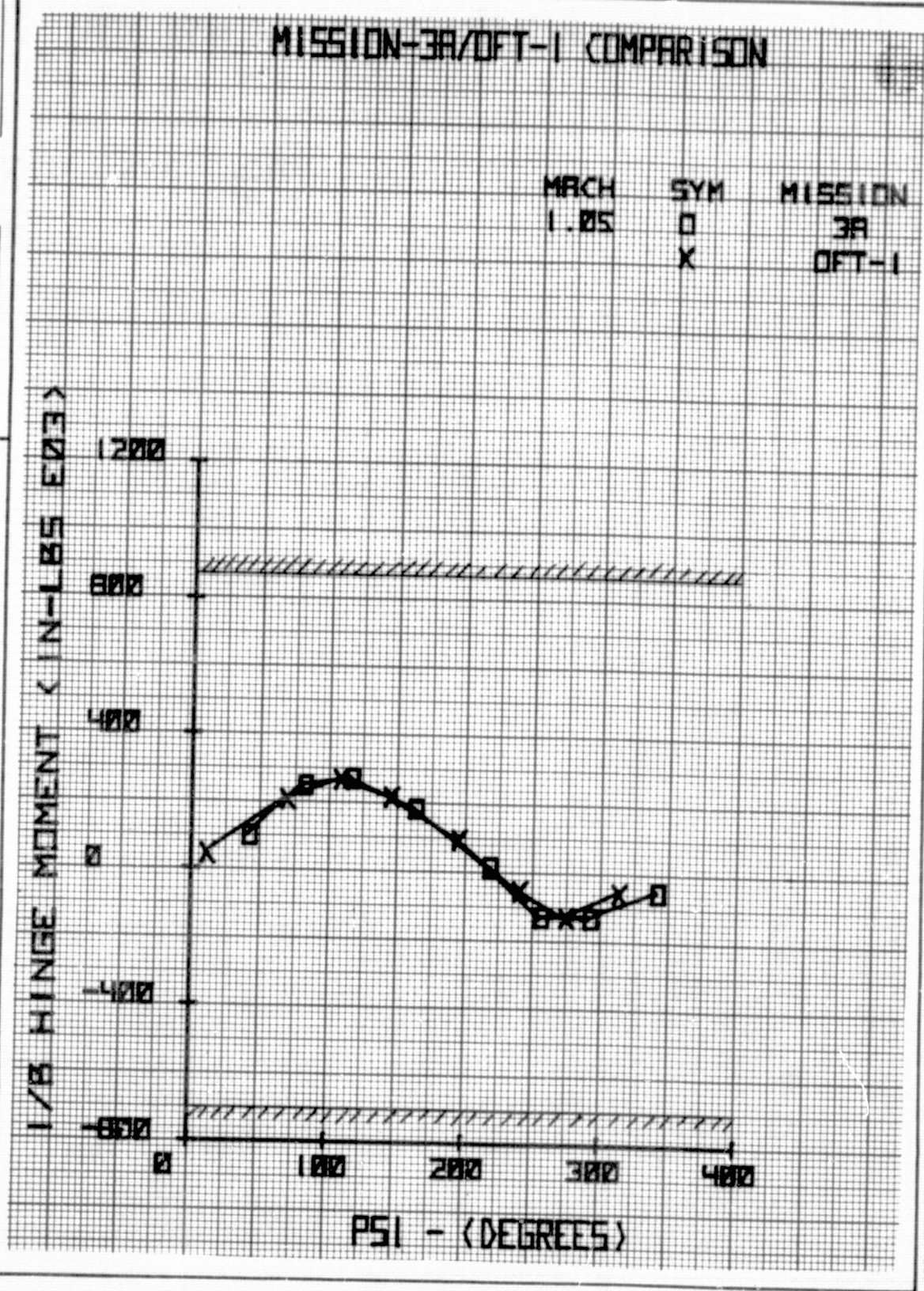


FIGURE 54.- SENSITIVITY OF RIGHT HMI TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX
BRANCH EX42 DATE
BY L. Austin PLOT NO.

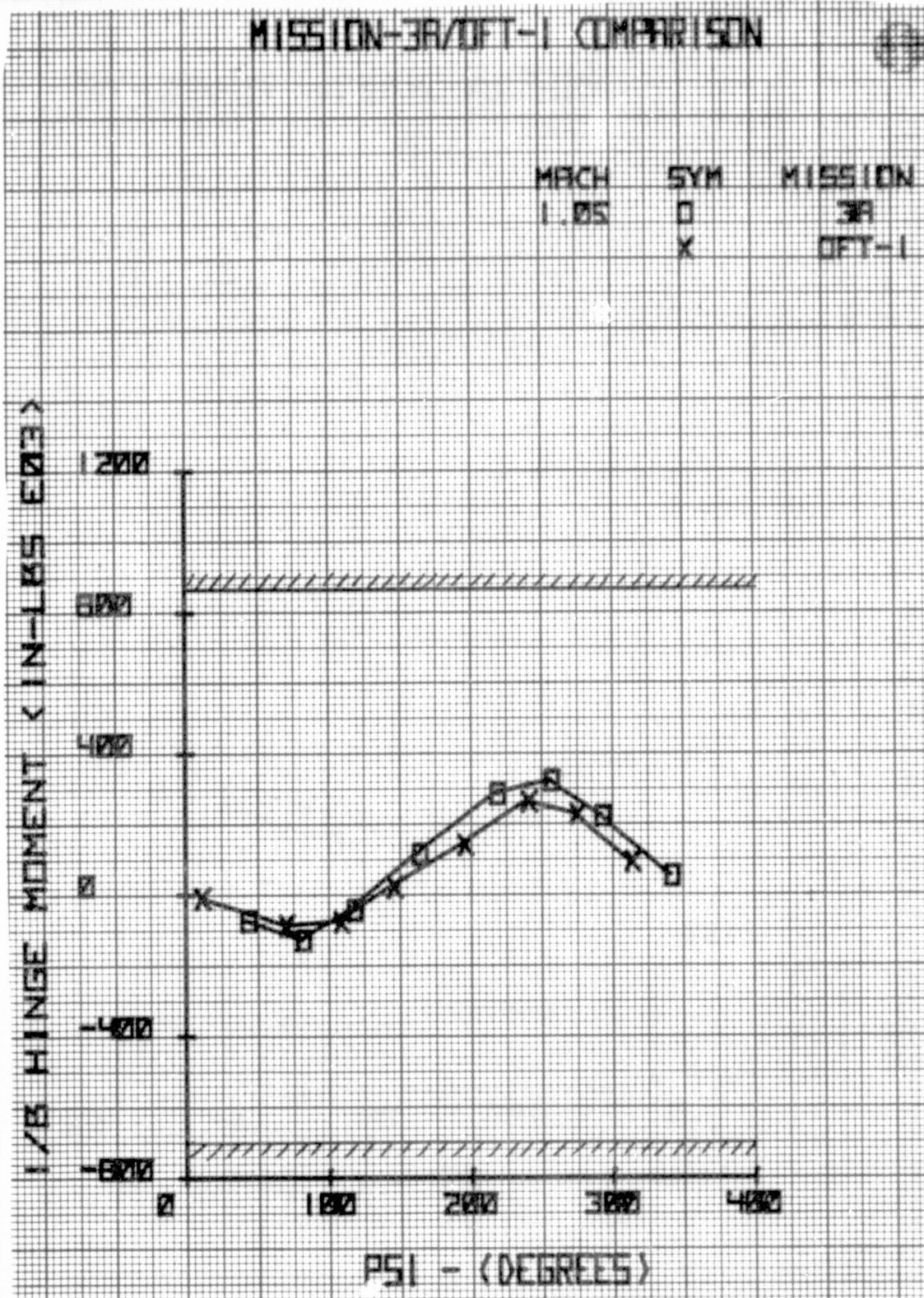


JSC FORM 1138 (MAR 73)

NASA-JSC

ENGINEERING ANALYSIS DIVISION/EX
 BRANCH EX42 DATE
 BY L. Austin PLOT NO.

FIGURE 55.- SENSITIVITY OF LEFT HMI TO VARIATIONS IN
 WIND DIRECTION

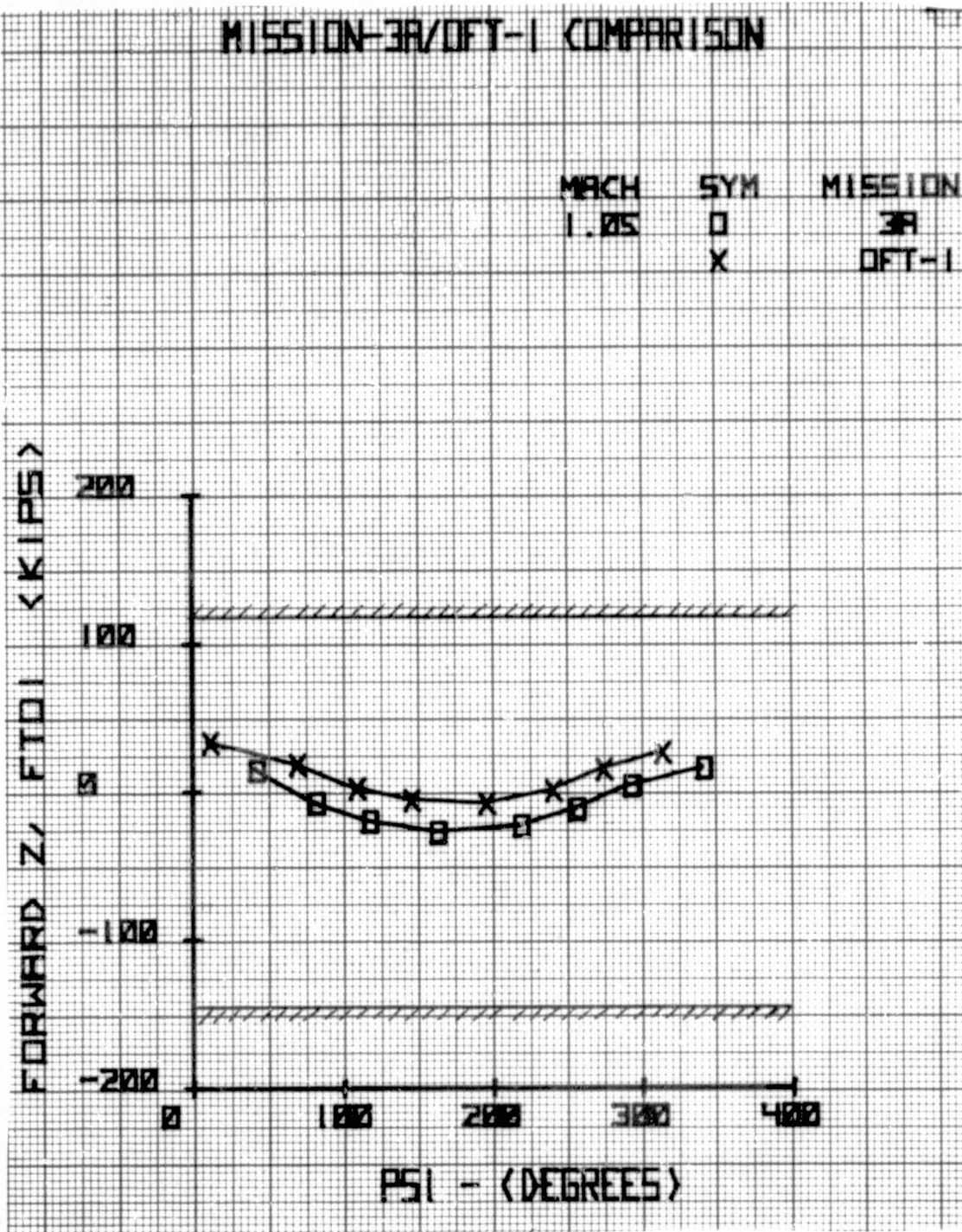


ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

FIGURE 56.- SENSITIVITY OF FT01 TO VARIATION IN WIND DIRECTION



JSC FORM 1138 (MAR 73)

NASA-JSC

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

FIGURE 57.- SENSITIVITY OF FT02 TO VARIATION IN WIND DIRECTION

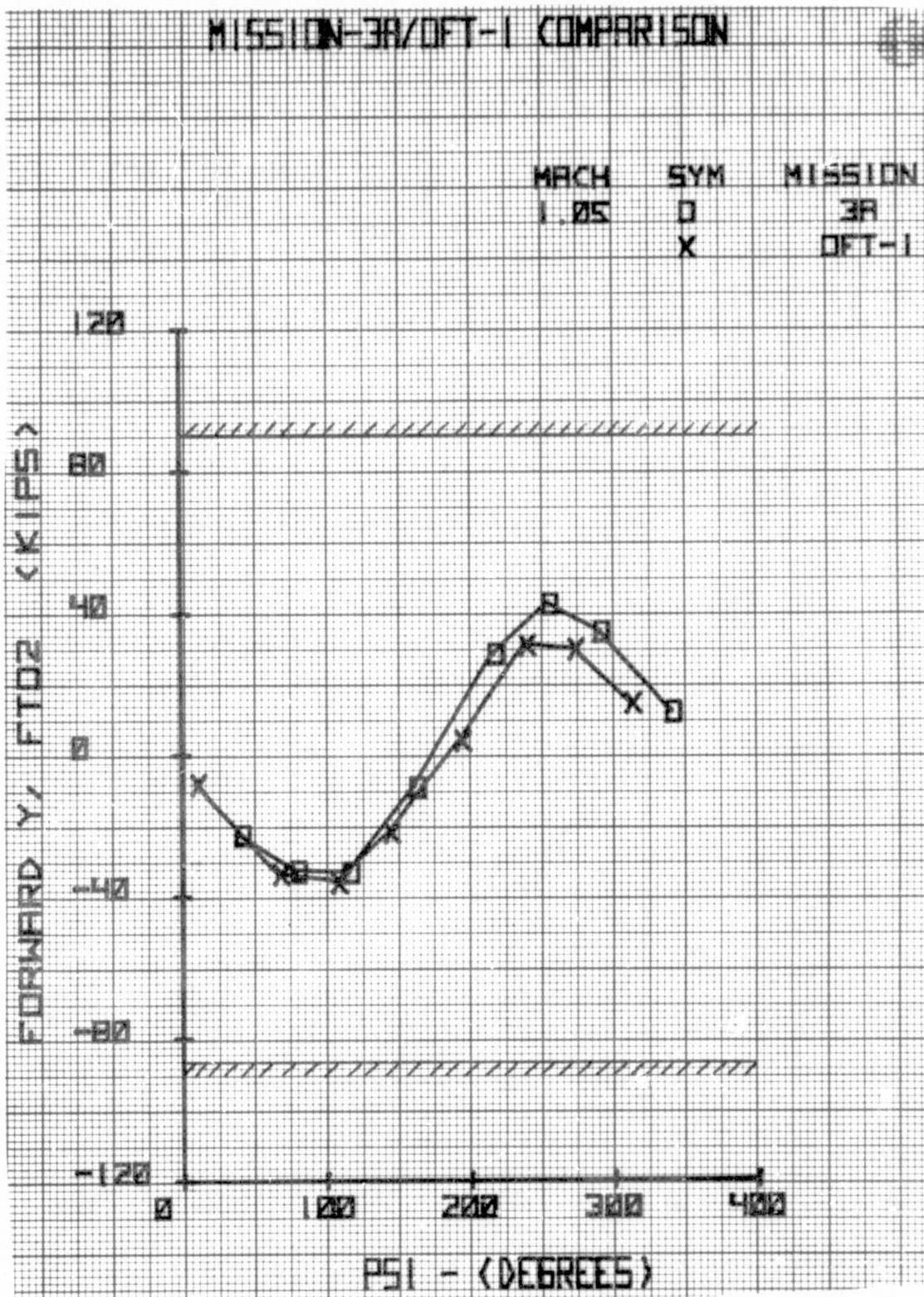


FIGURE 58.- SENSITIVITY OF FT03 TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

MISSION-3R/OFT-1 COMPARISON

ARCH 1.05
SYM D
MISSION 3R
OFT-1

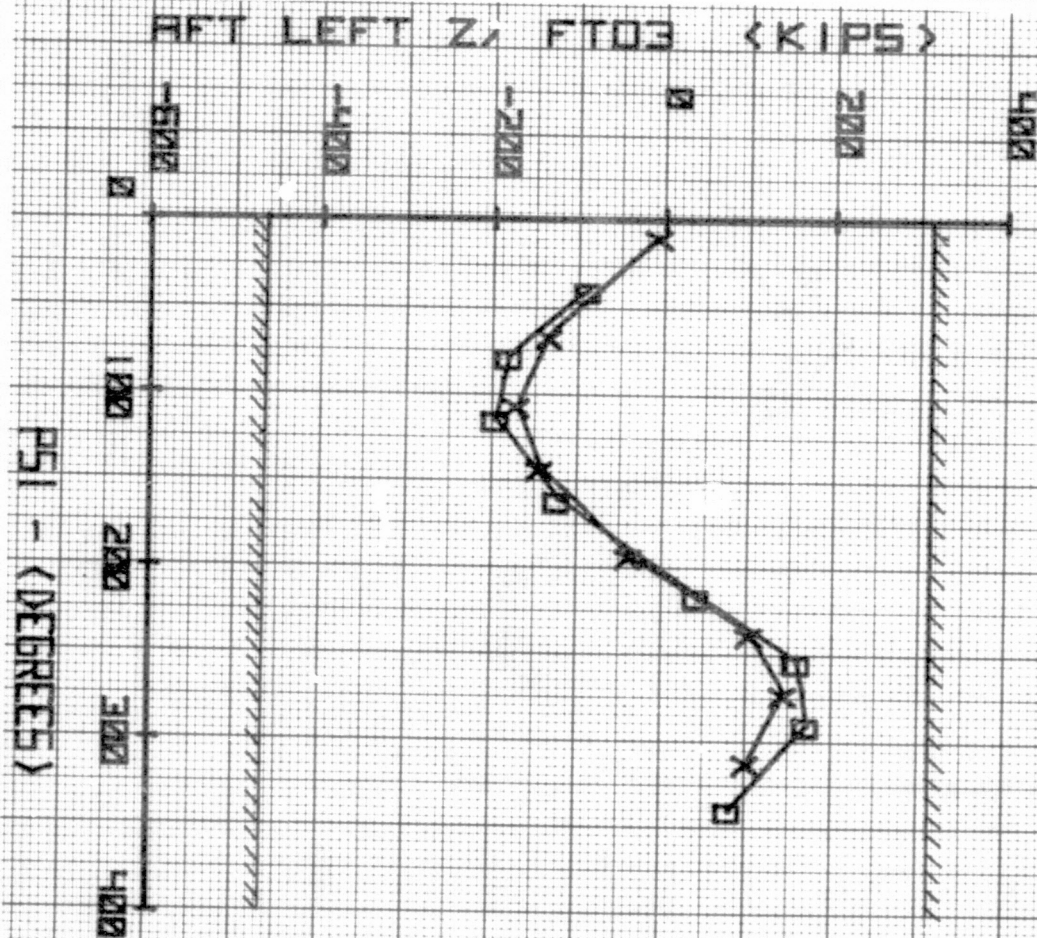


FIGURE 59.- SENSITIVITY OF FT04 TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

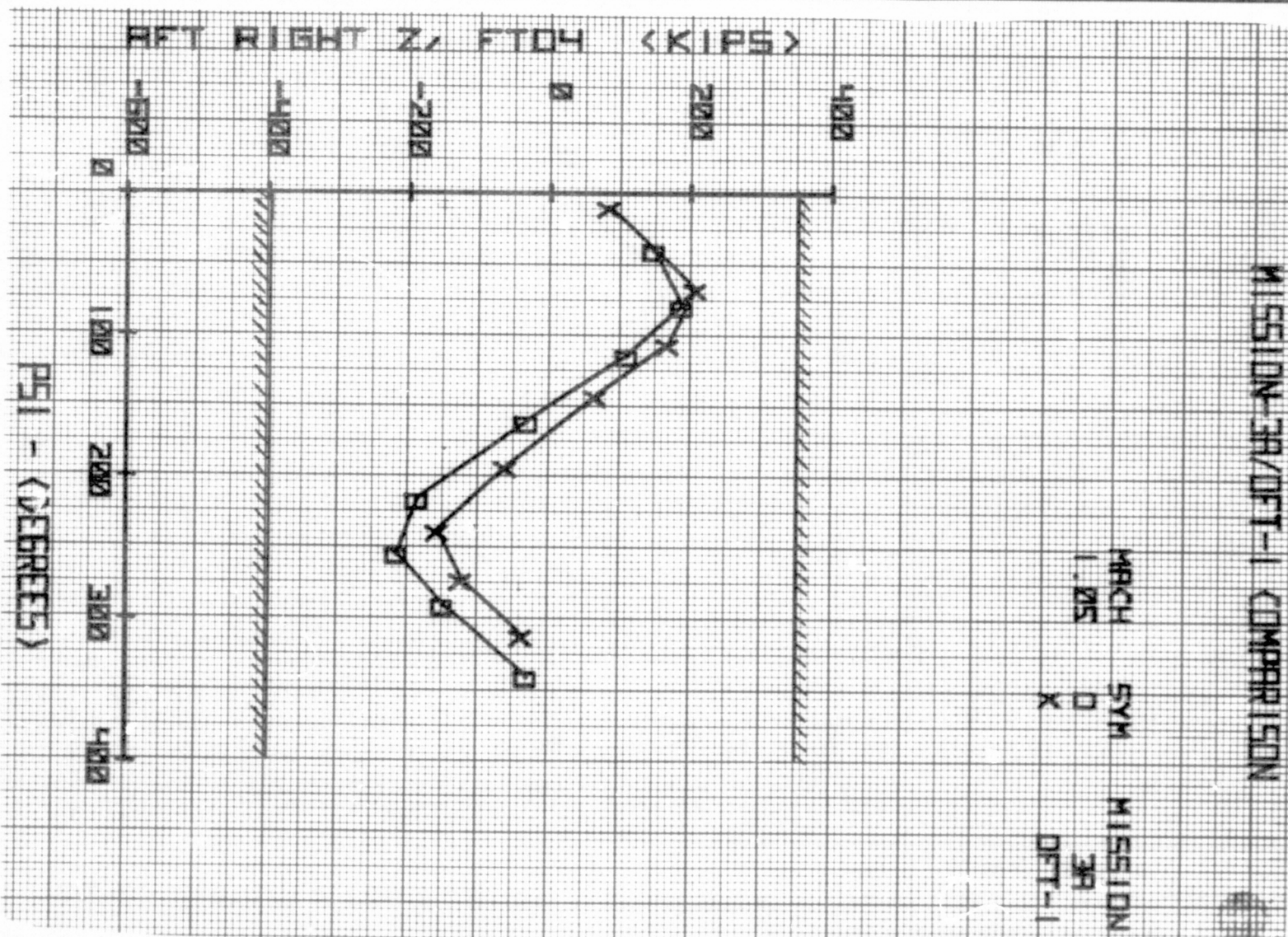


FIGURE 60.- SENSITIVITY OF FT06 TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE _____

BY L. Austin PLOT NO. _____

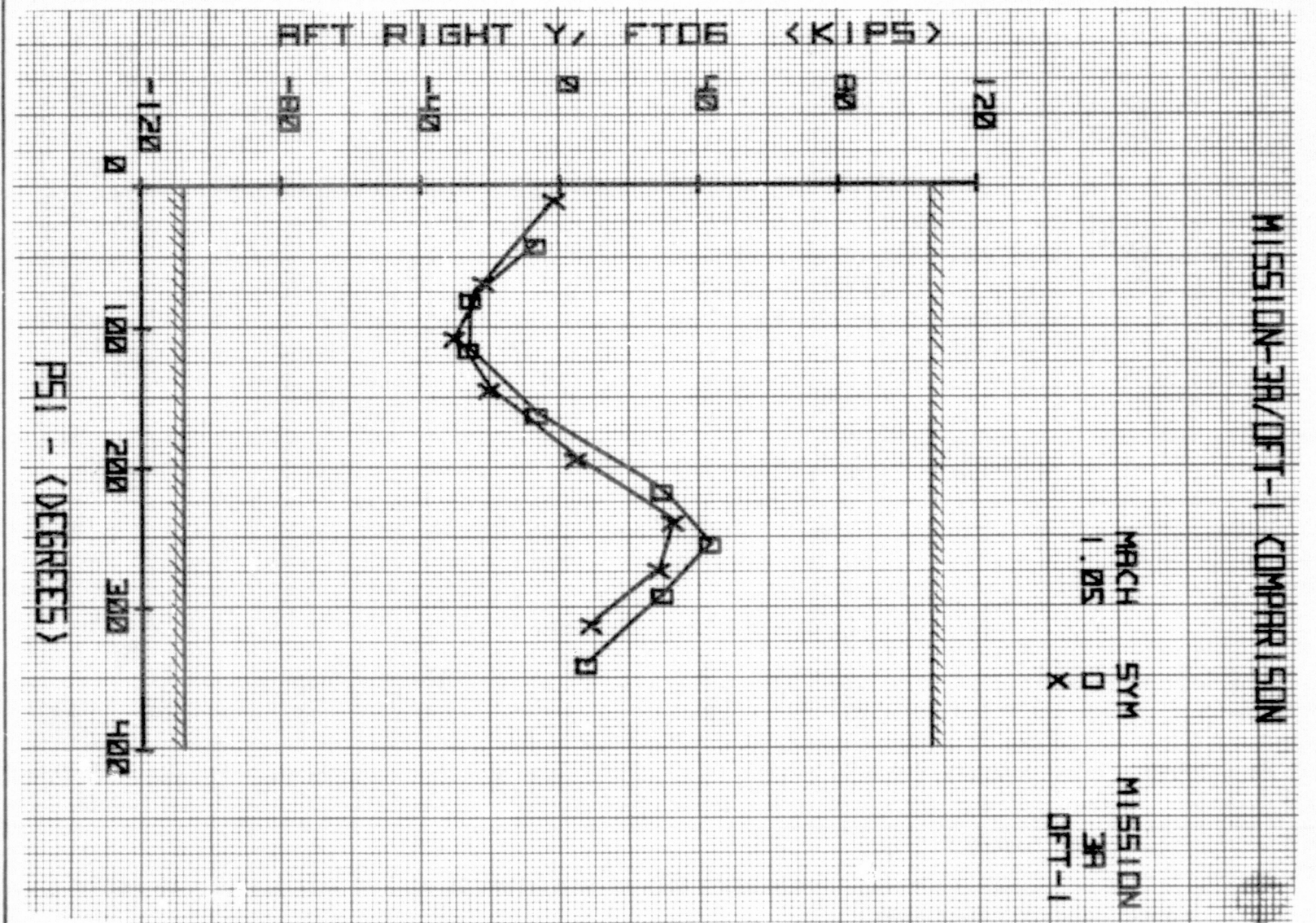


FIGURE 61.- SENSITIVITY OF FT07 TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

BY L. Austin

PLOT NO.

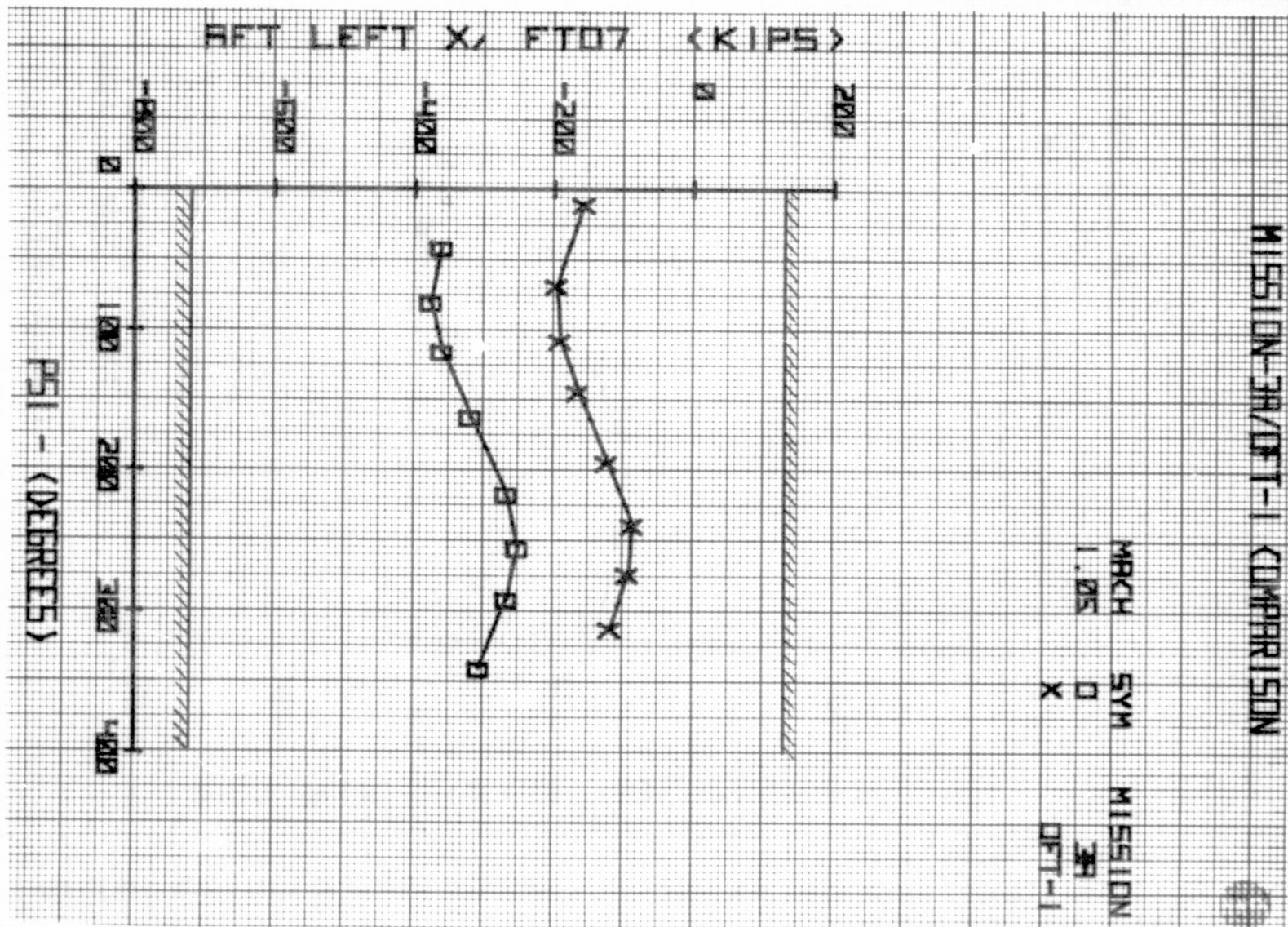


FIGURE 62.- SENSITIVITY OF FT08 TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

BY L. Austin

PLOT NO.

MISSION-3R/DFT-1 COMPARISON

MRCH 1.05
SYM D
MISSION 3R
DFT-1

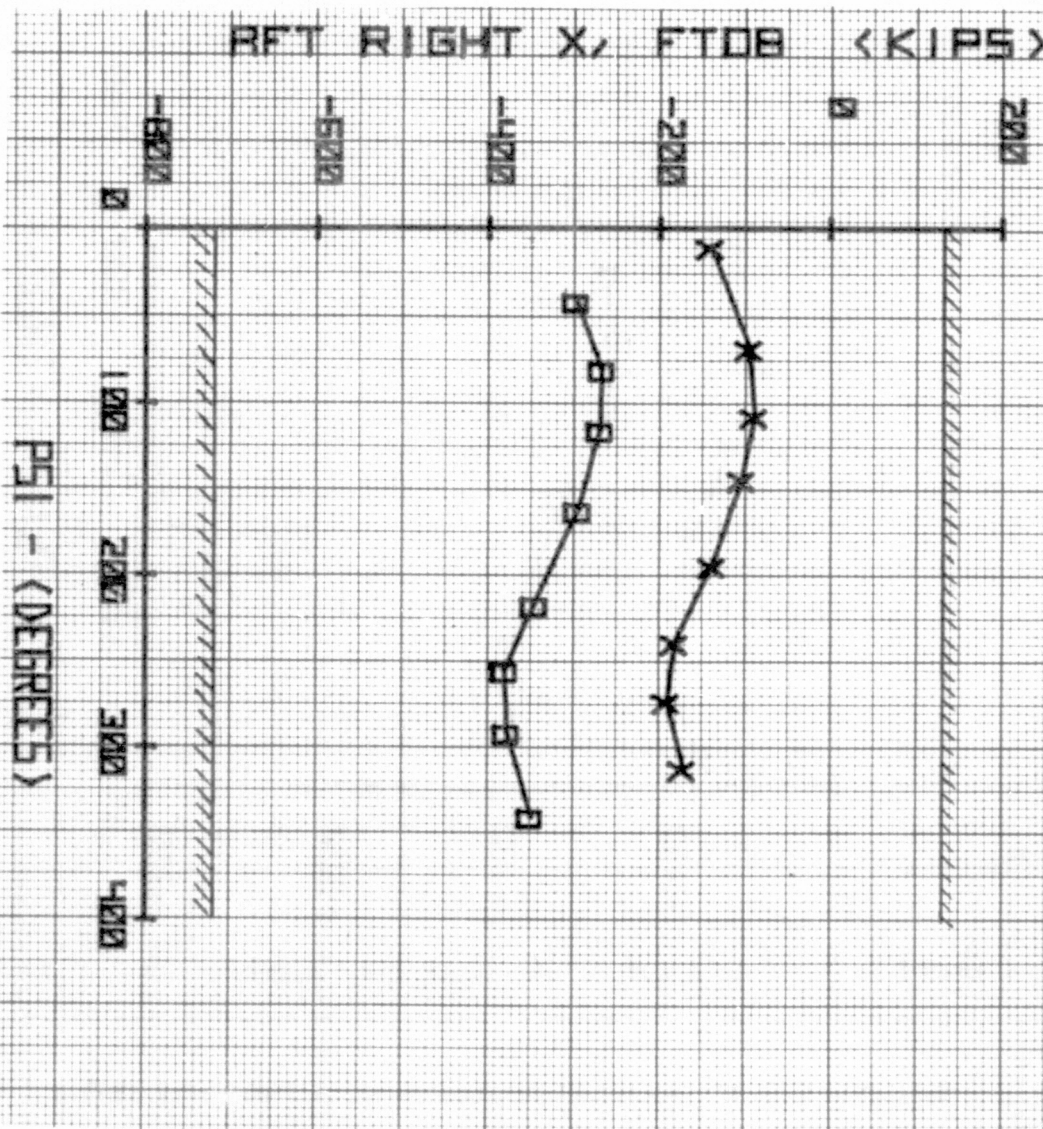


FIGURE 63.- SENSITIVITY OF FTBI TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

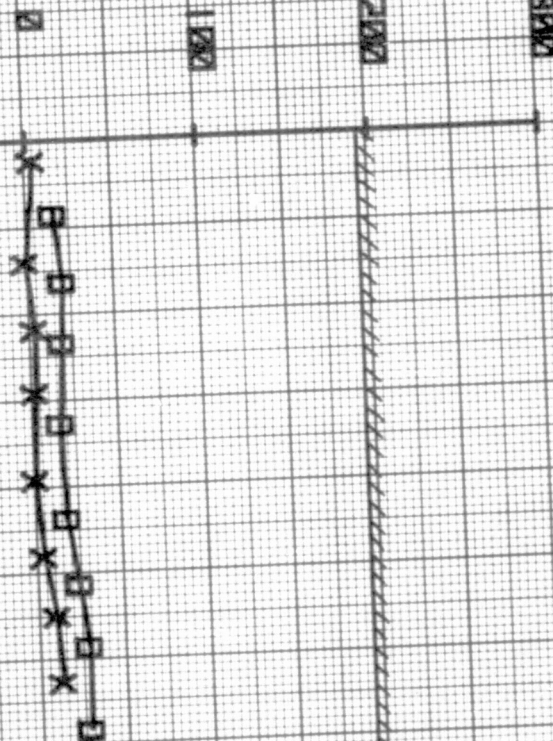
BY L. Austin PLOT NO.

FORWARD LEFT Z, FTBI (KIPS)

PSI - (DEGREES)

MISSION-3R/DFT-1 COMPARISON

MRCH 1.05
SYM D
MISSION 3R
DFT-1



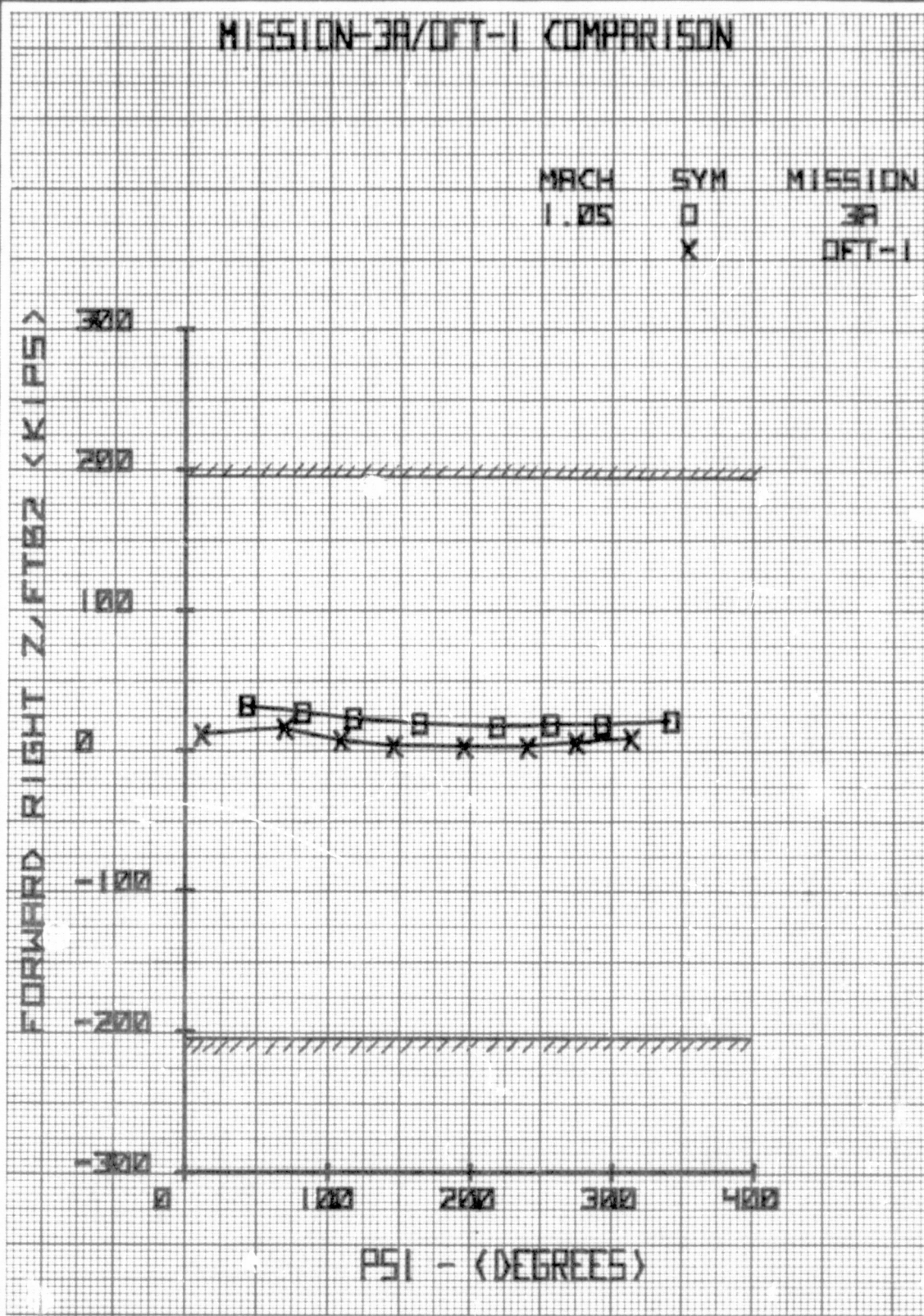
NASA-JSC

FIGURE 64.- SENSITIVITY OF FTB2 TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

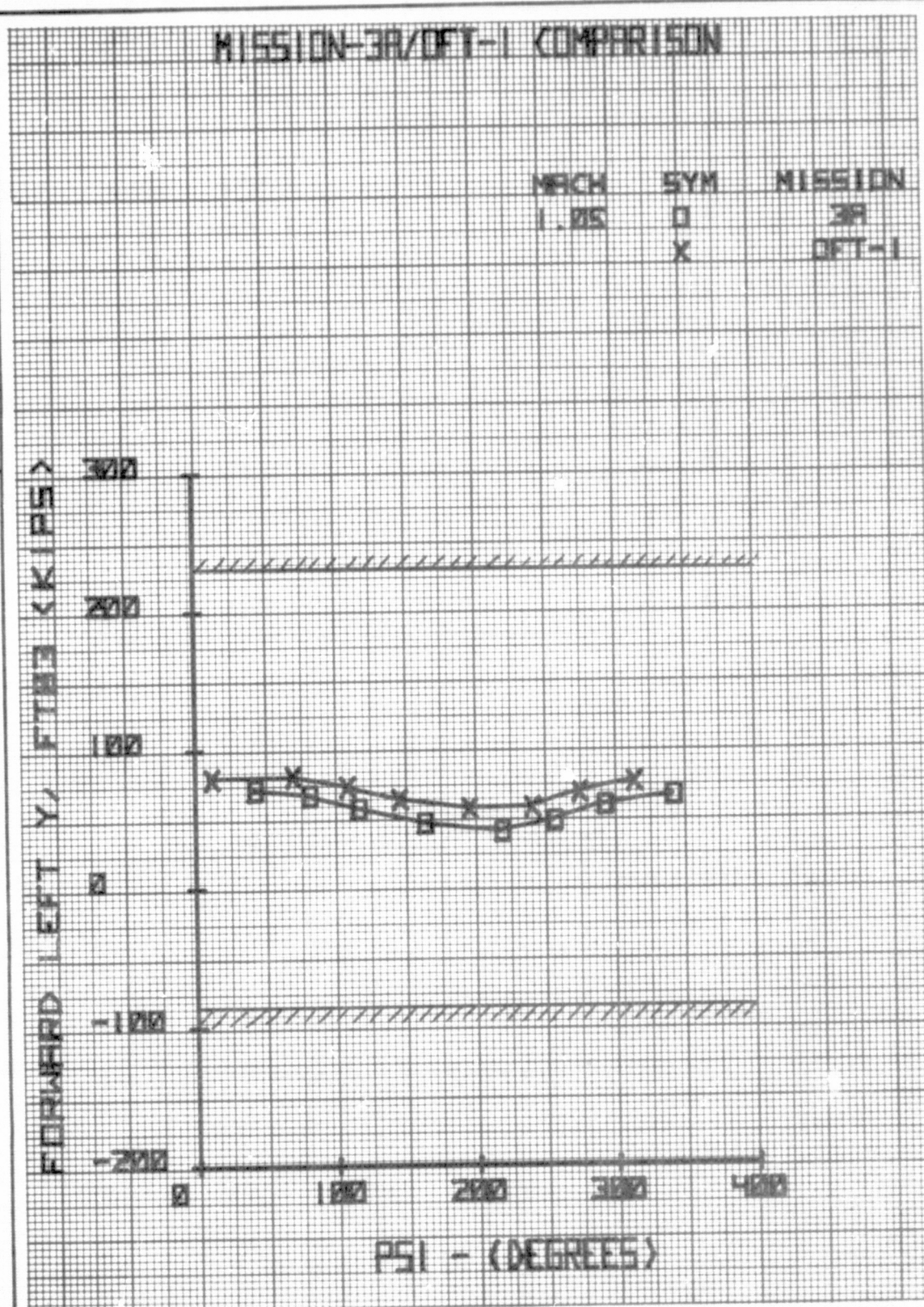


ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

FIGURE 65.- SENSITIVITY OF FTB3 TO VARIATIONS IN WIND DIRECTION



NASA-JSC

JSC FORM 1138 (MAR 73)

FIGURE 66.- SENSITIVITY OF FTB4 TO VARIATIONS IN WIND DIRECTION

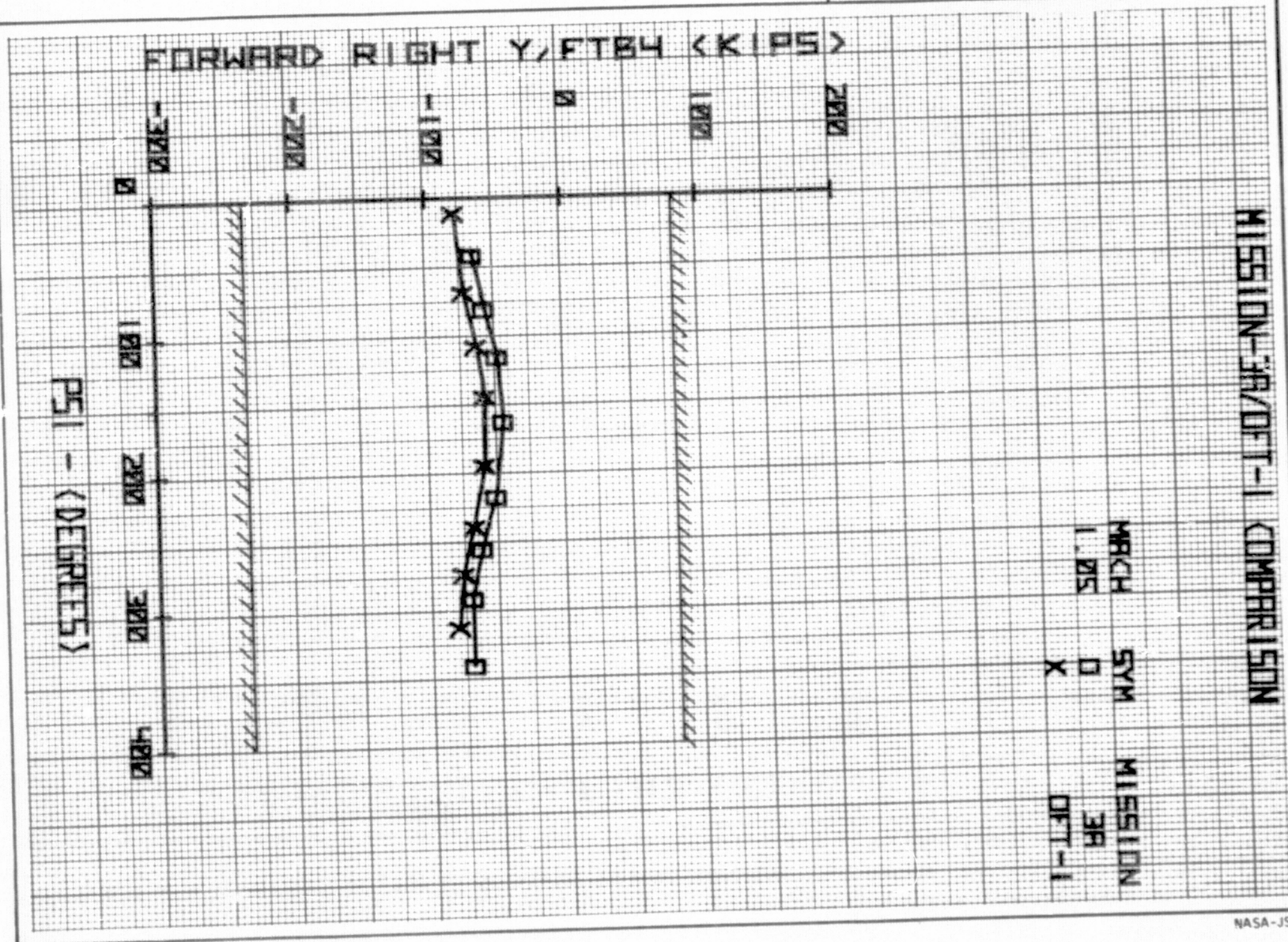
ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE _____

BY L. Austin

PLOT NO. _____



NASA-JSC

FIGURE 67.- SENSITIVITY OF FTB5 TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

BY L. Austin

PLOT NO.

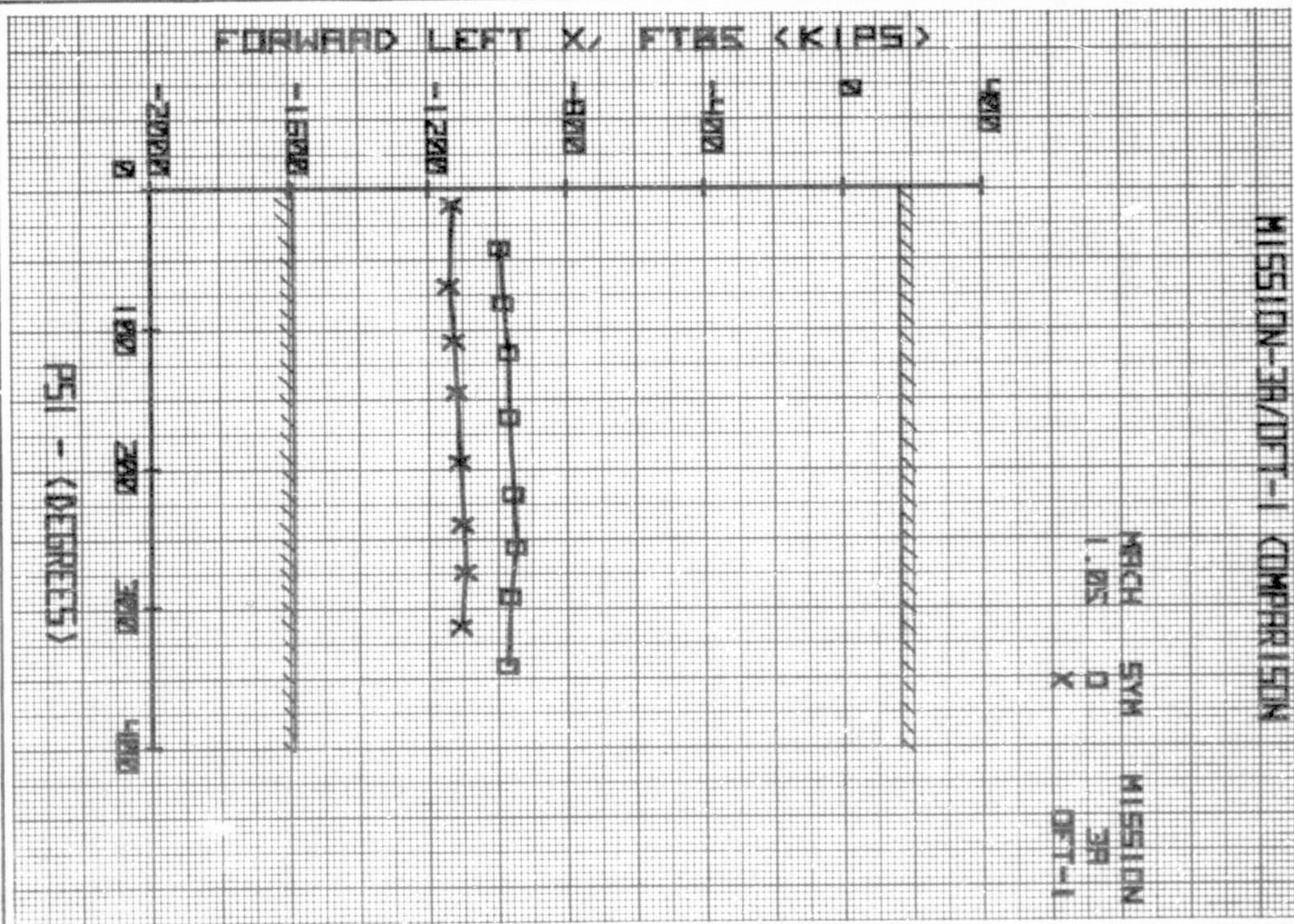


FIGURE 68.- SENSITIVITY OF FTB6 TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

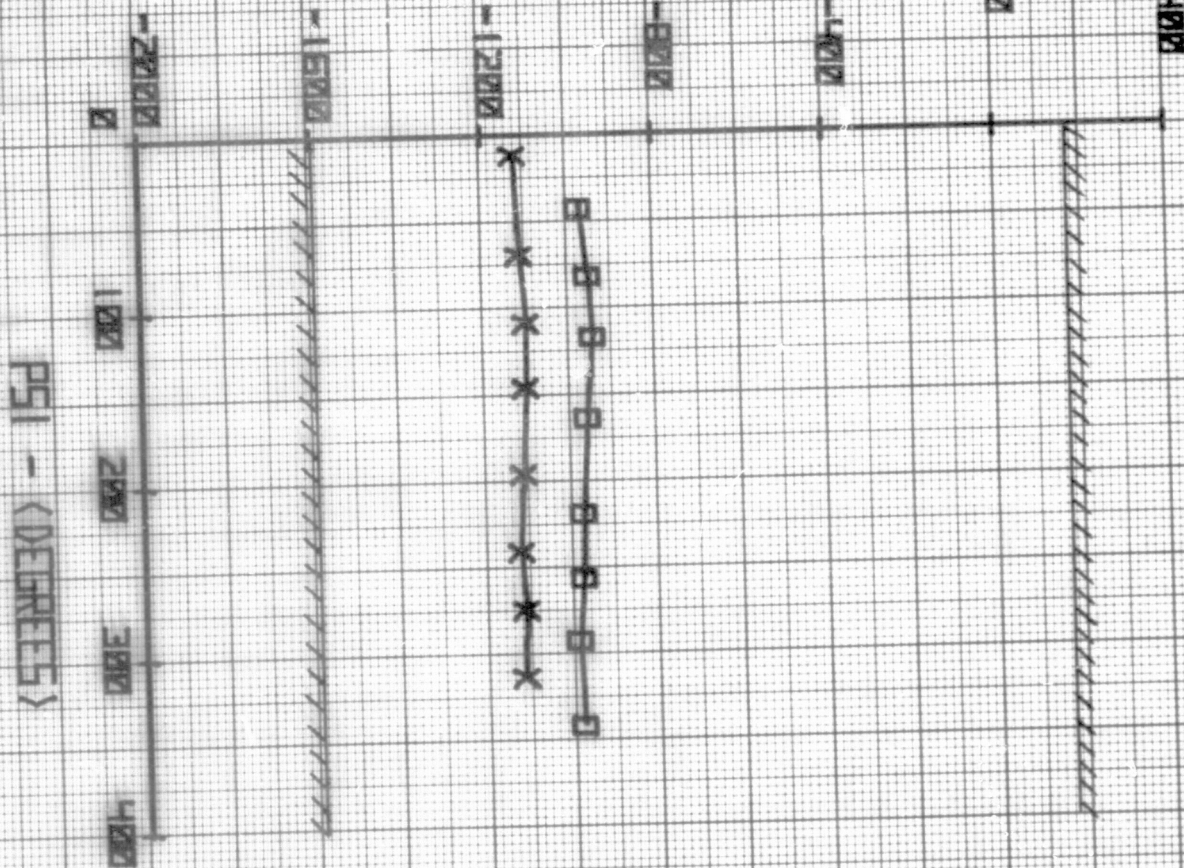
BY L. Austin

PLOT NO.

MISSION-3R/OFT-1 COMPARISON

MRCH 1.05
SYM D
MISSION 3R/OFT-1

FORWARD RIGHT X/FTB6 (KIPS)



NASA-JSC

FIGURE 69.- SENSITIVITY OF FTB7 TO VARIATIONS IN WIND DIRECTION

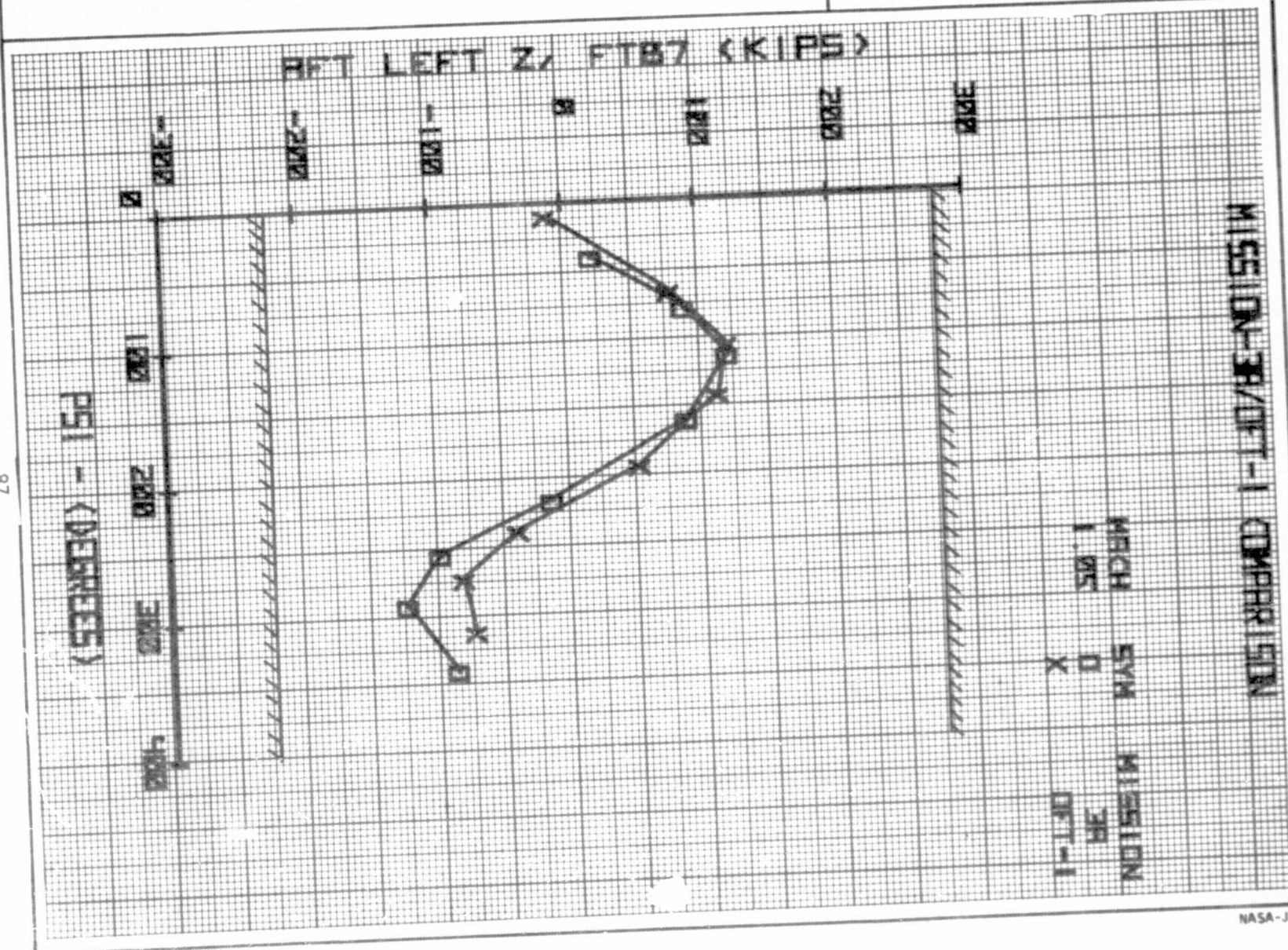
ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

BY L. Austin

PLOT NO.



NASA-JSC

FIGURE 70.- SENSITIVITY OF FTB8 TO VARIATIONS IN WIND DIRECTION

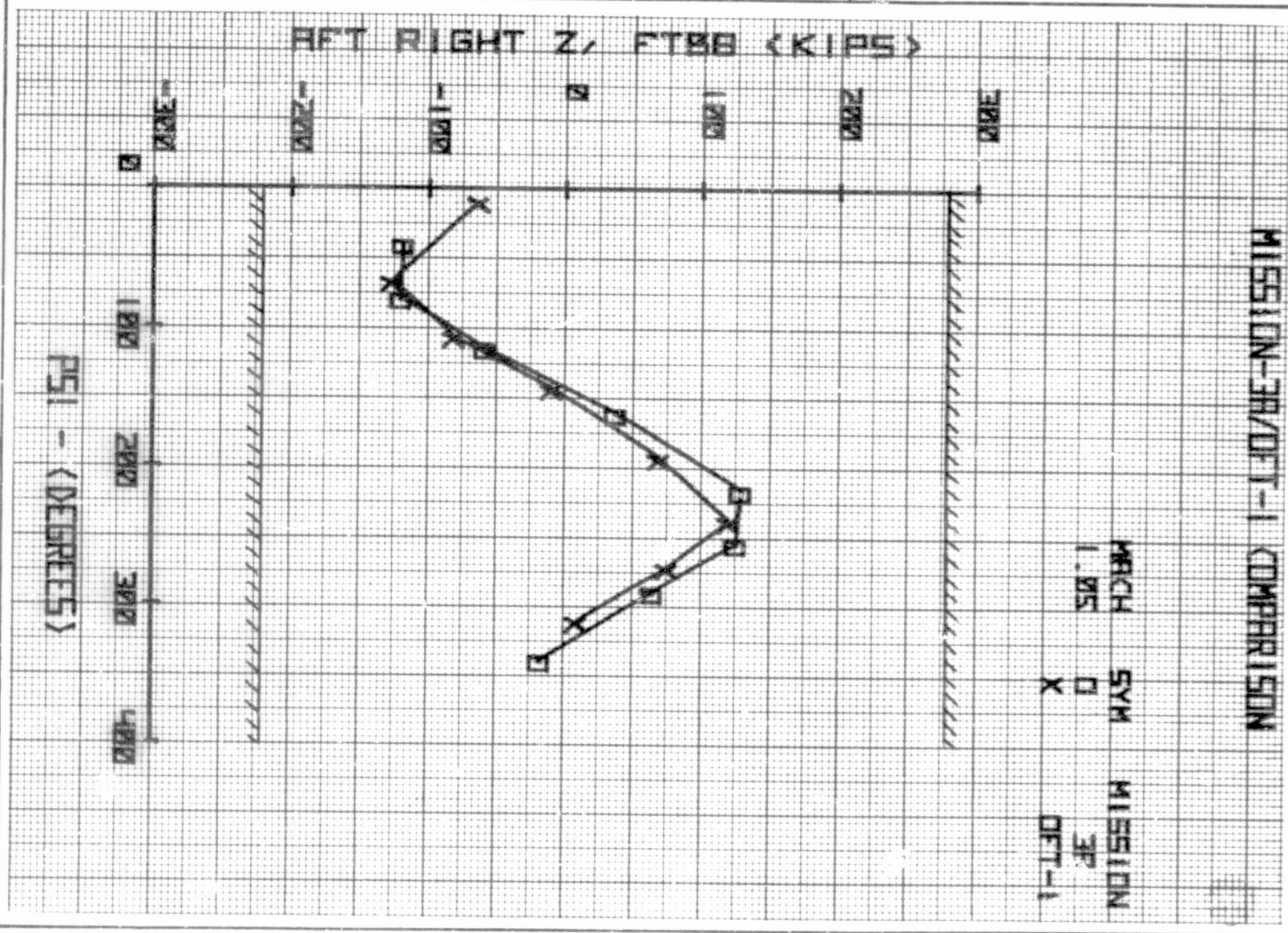
ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

BY L. Austin

PLOT NO.



0-2

ENGINEERING ANALYSIS DIVISION/EX	
BRANCH EX42	DATE
BY L. Austin	PLOT NO.

FIGURE 71.- SENSITIVITY TO FTB9 TO VARIATIONS IN WIND DIRECTION

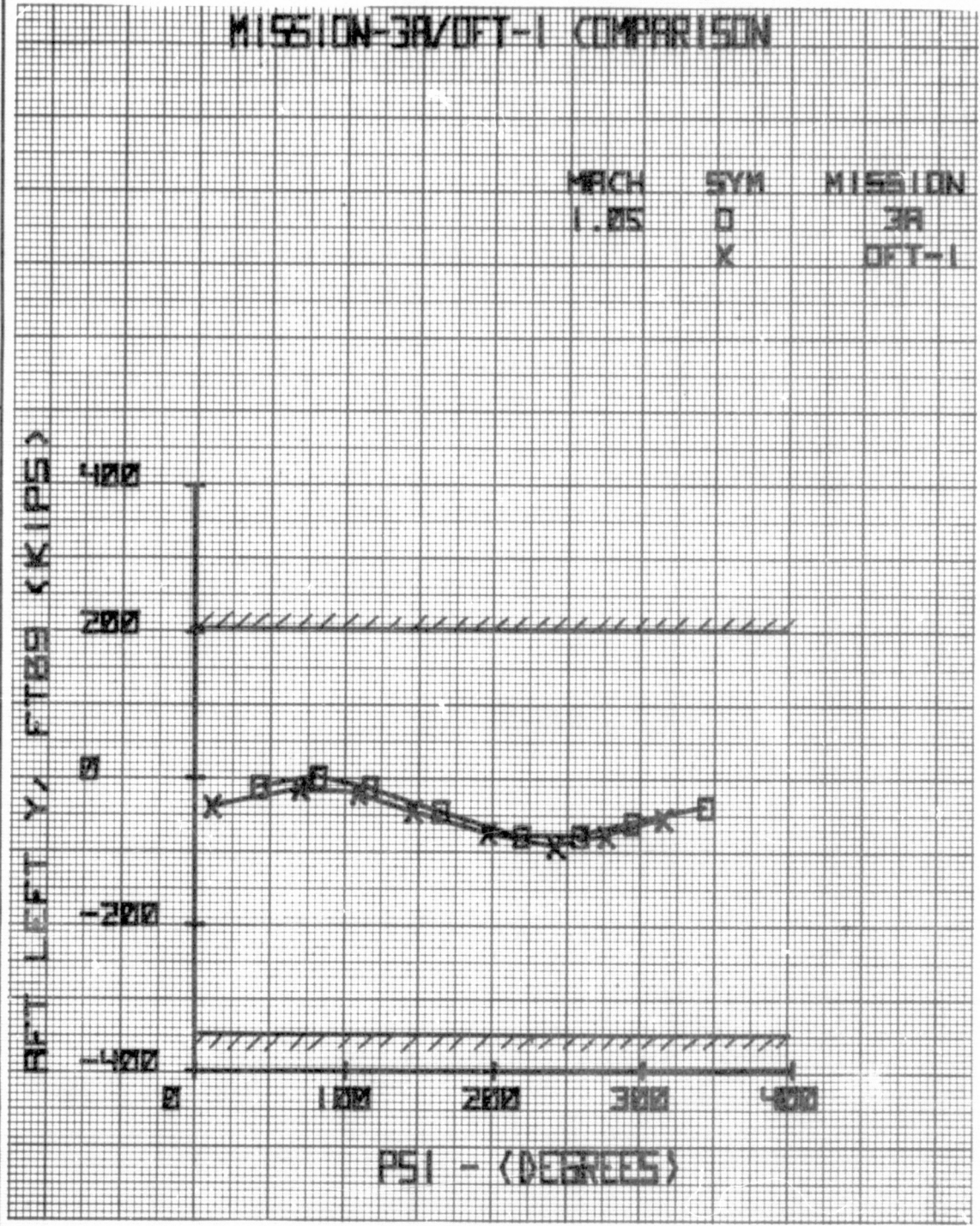


FIGURE 72.- SENSITIVITY OF FTB10 TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

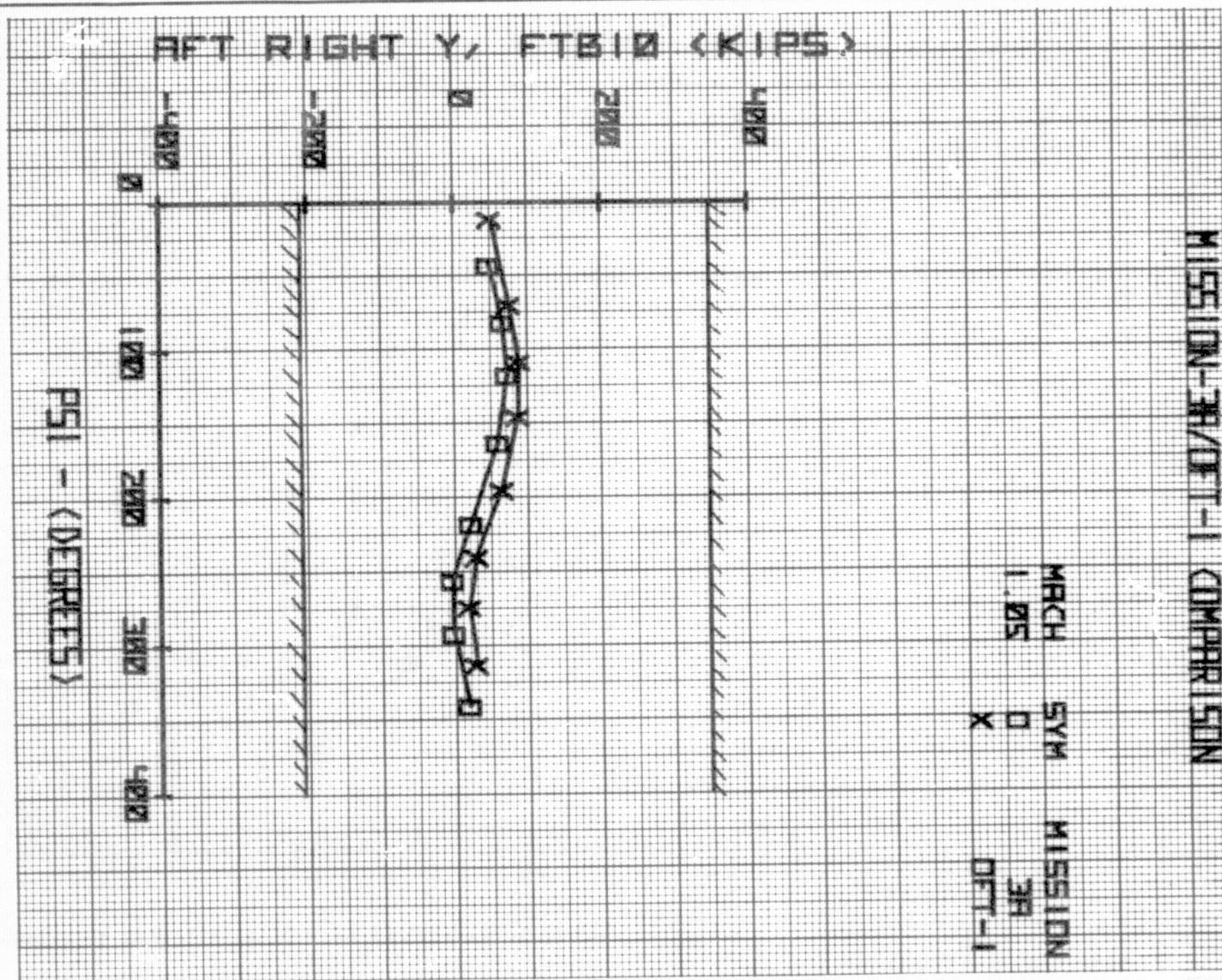


FIGURE 73.- SENSITIVITY OF MTB1 TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

BY L. Austin

PLOT NO.

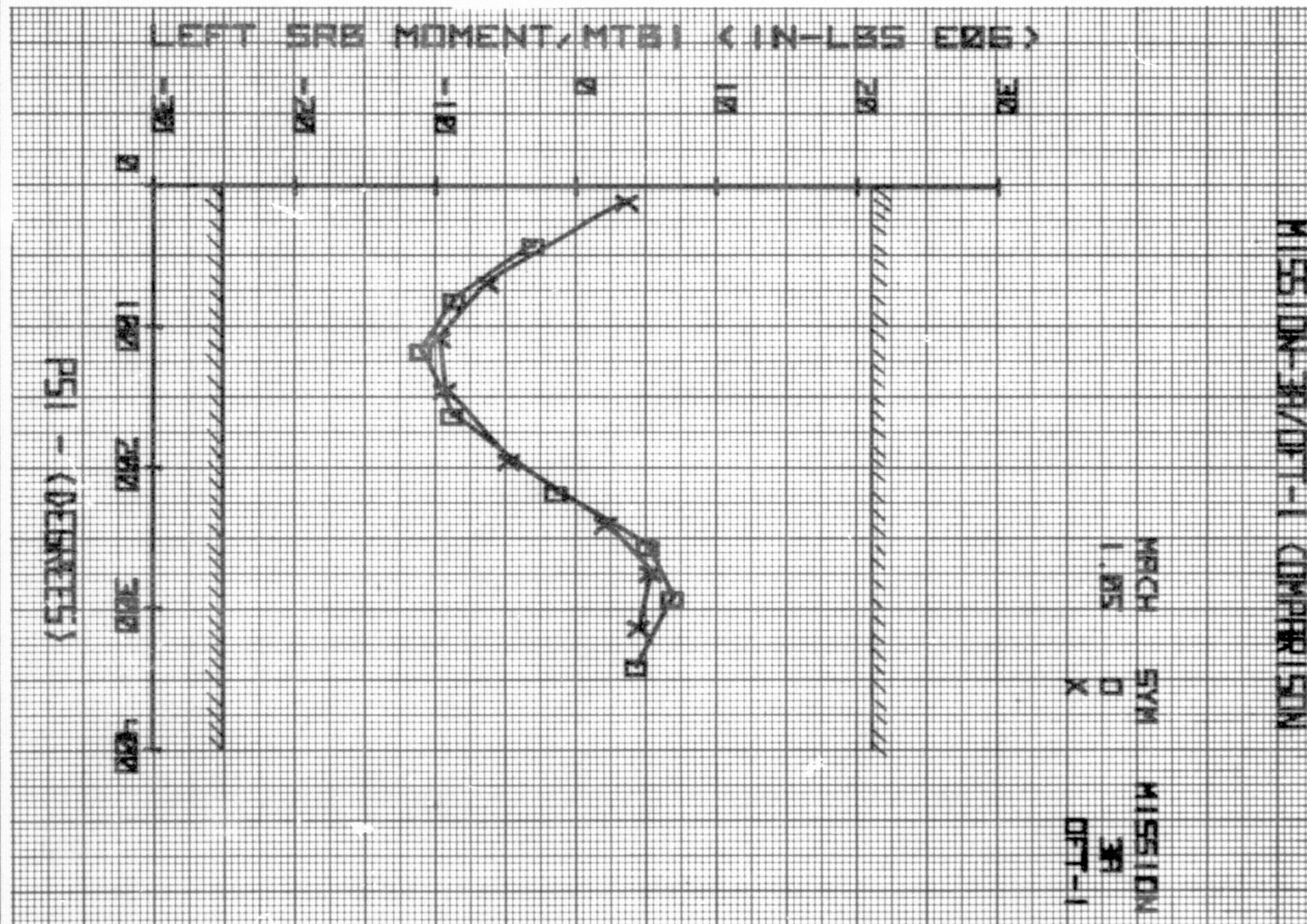


FIGURE 74.- SENSITIVITY OF MTB2 TO VARIATIONS IN WIND DIRECTION

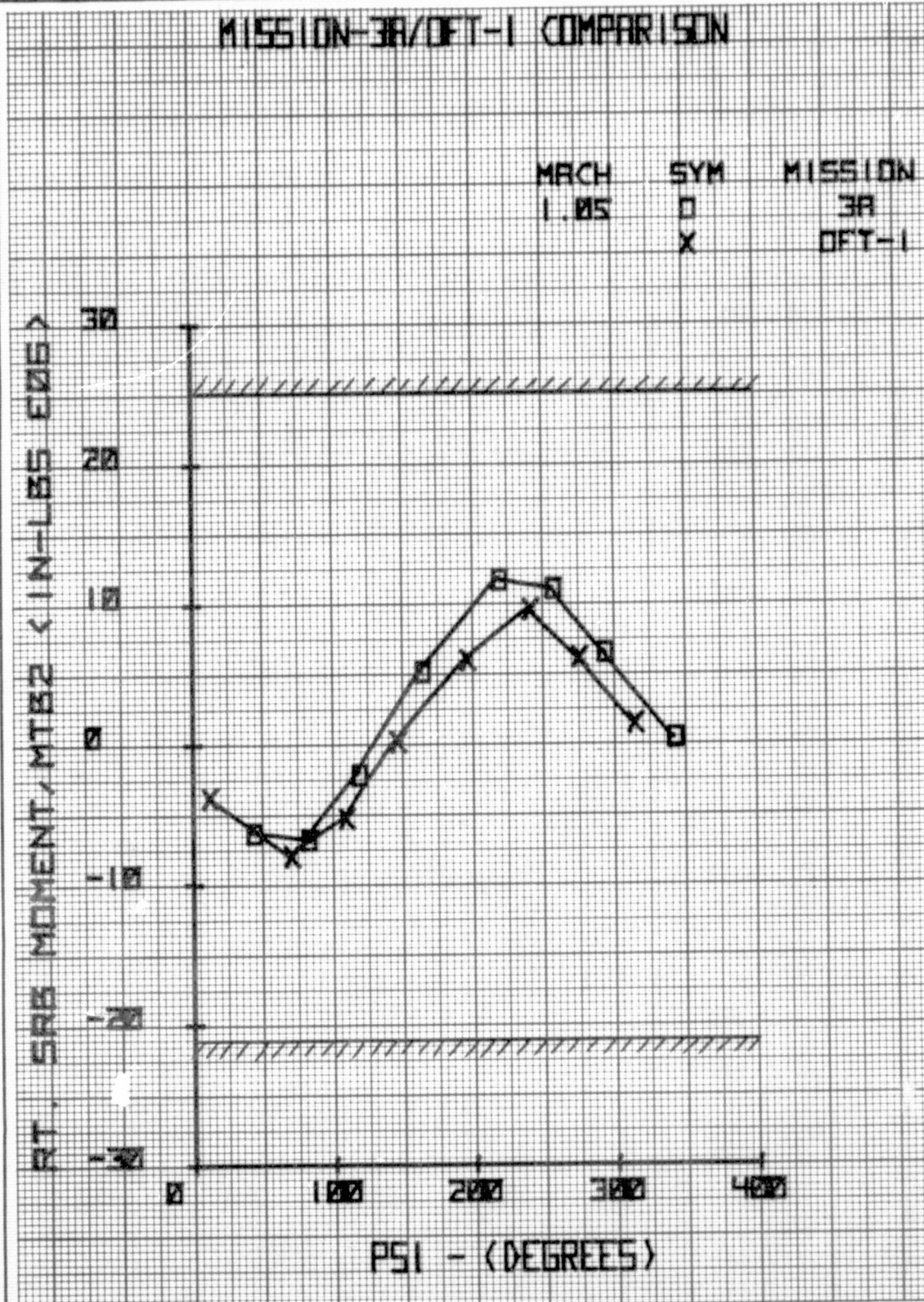


FIGURE 75.- OFT-1/3A SQUATCHELOIDS

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

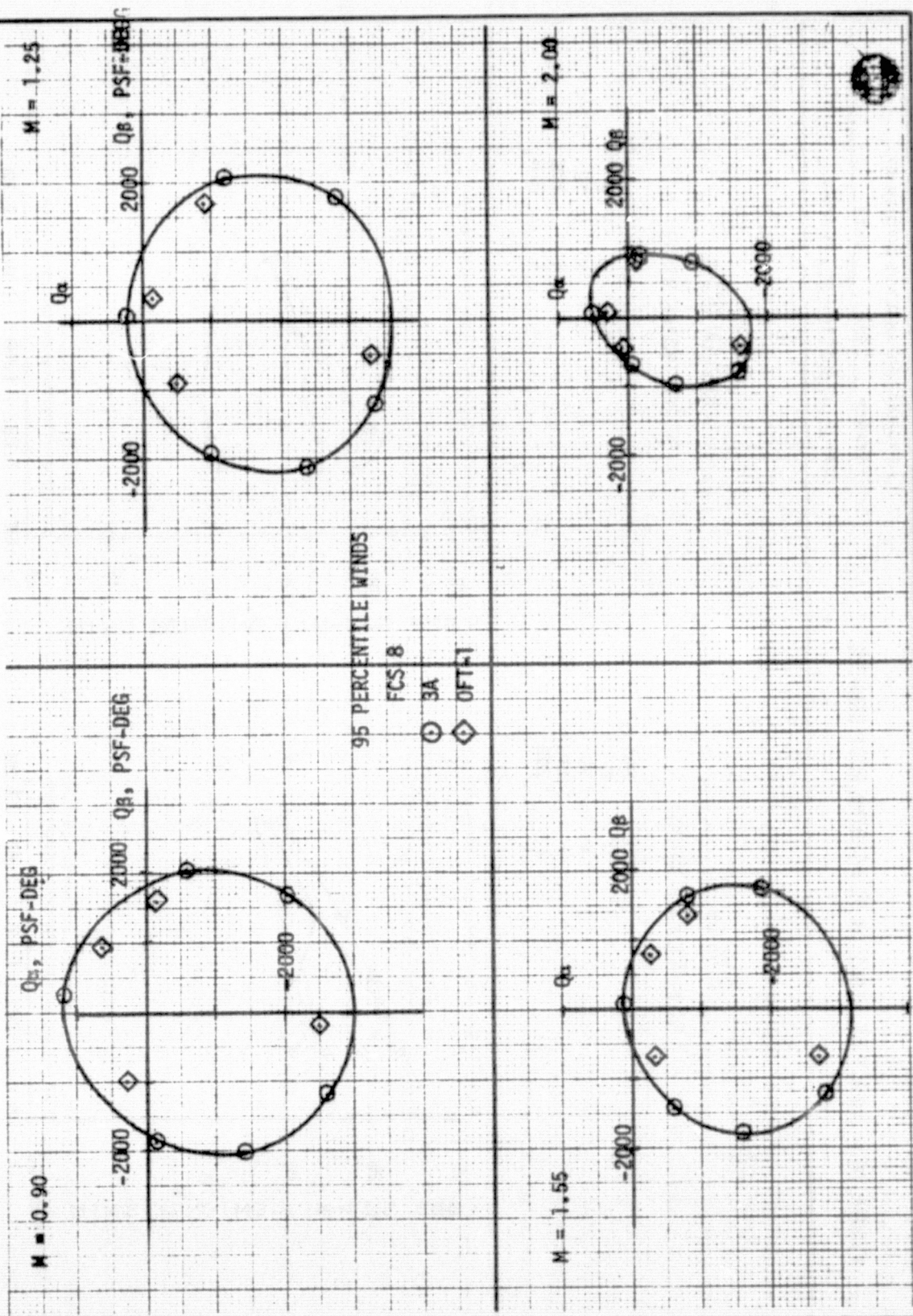


FIGURE 76.- IMPACT OF WINDS ON RIGHT WING ROOT BENDING

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

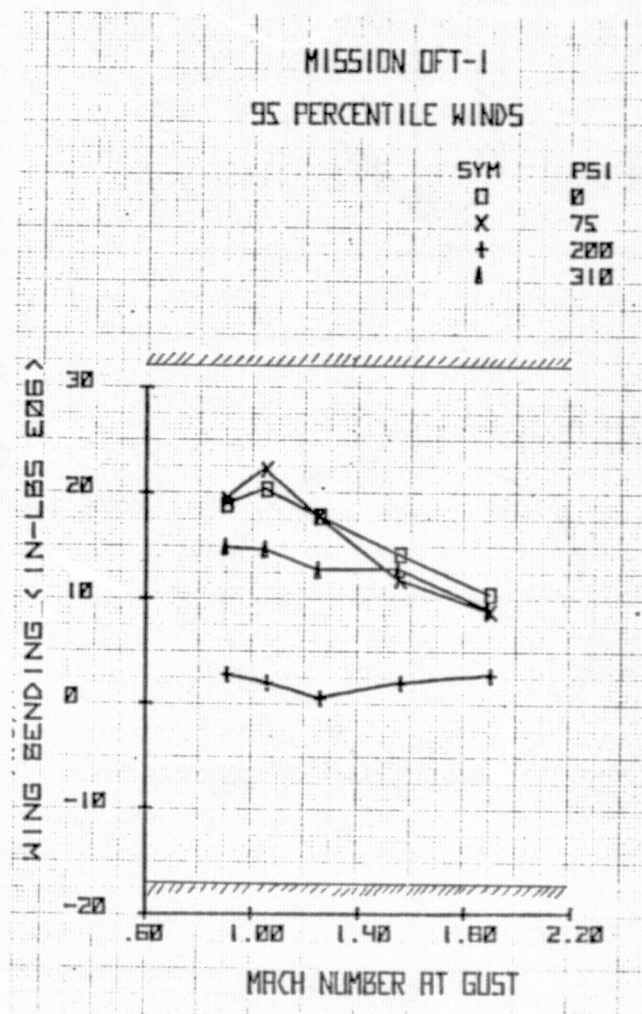
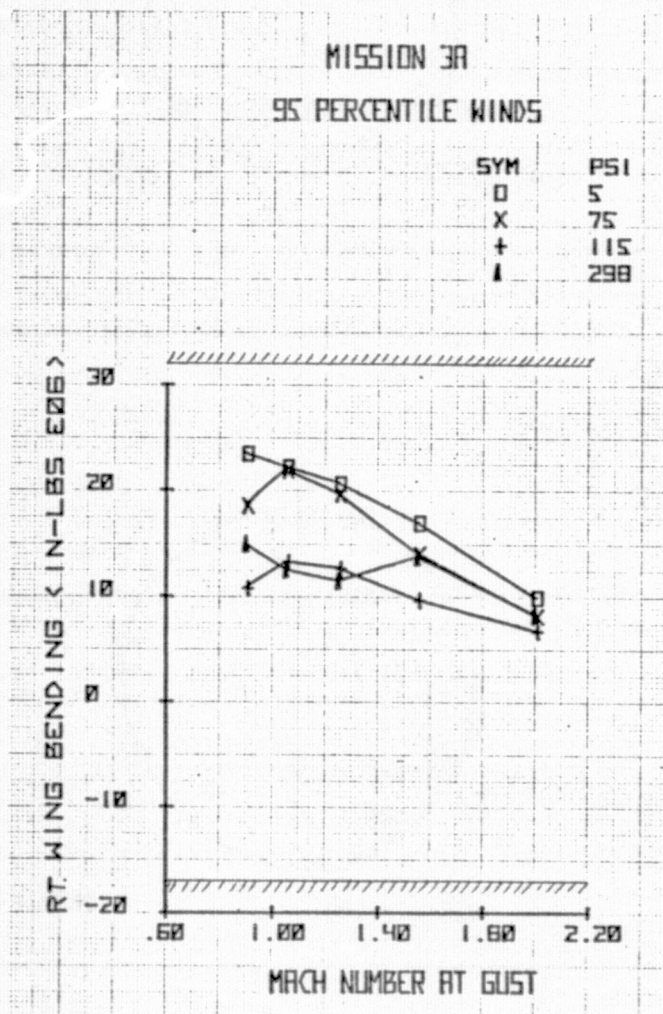
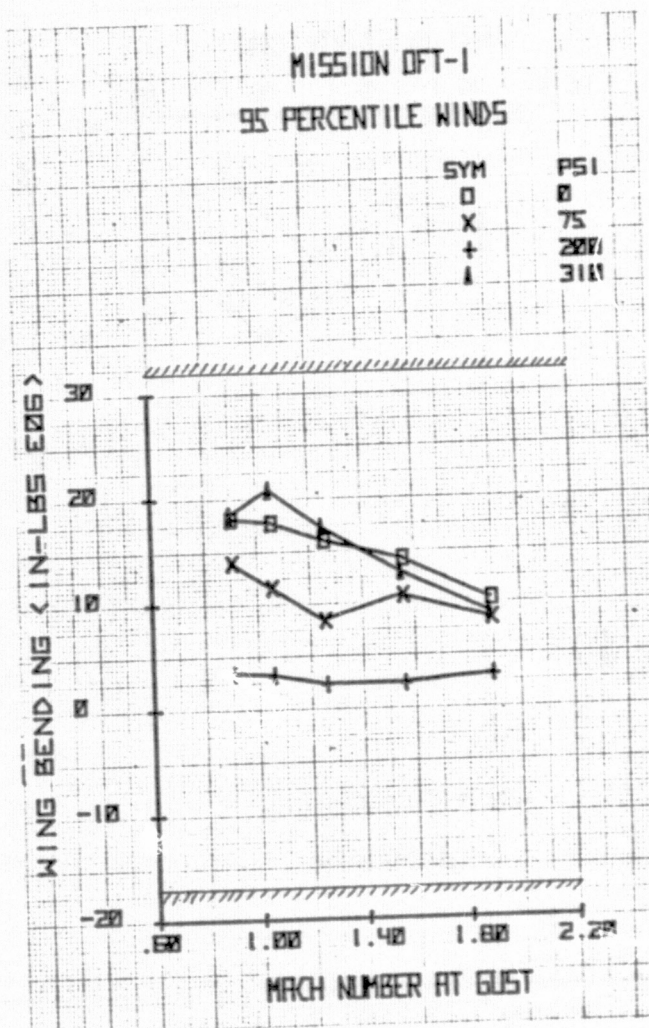
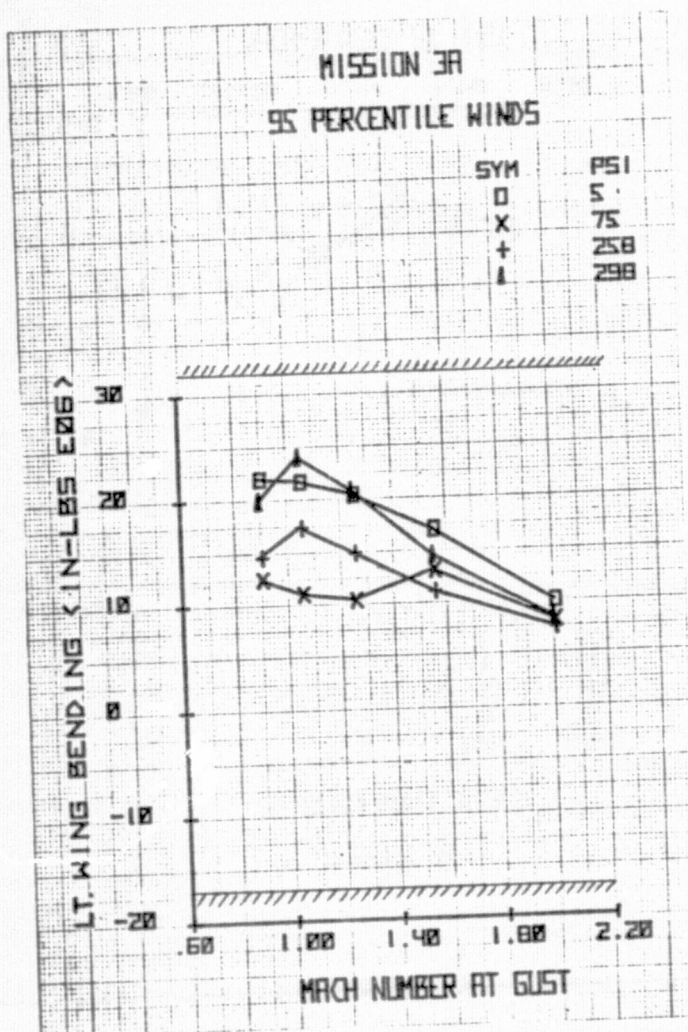


FIGURE 77.- IMPACT OF WINDS ON LEFT WING ROOT BENDING

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.



NASA-JSC

FIGURE 78.- IMPACT OF WINDS ON RIGHT WING ROOT TORSION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

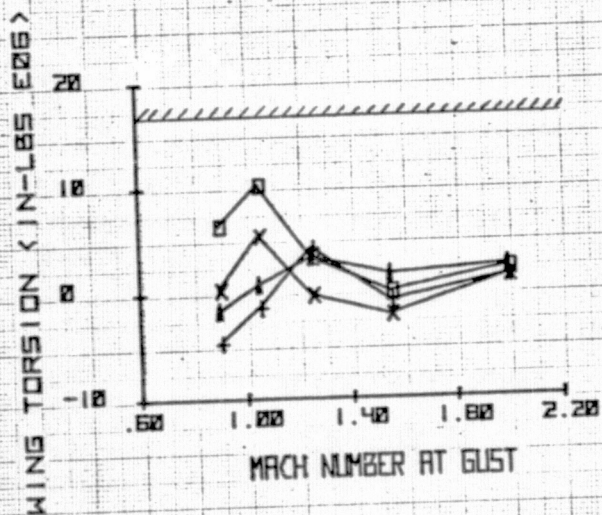
DATE _____

BY L. Austin

PLOT NO. _____

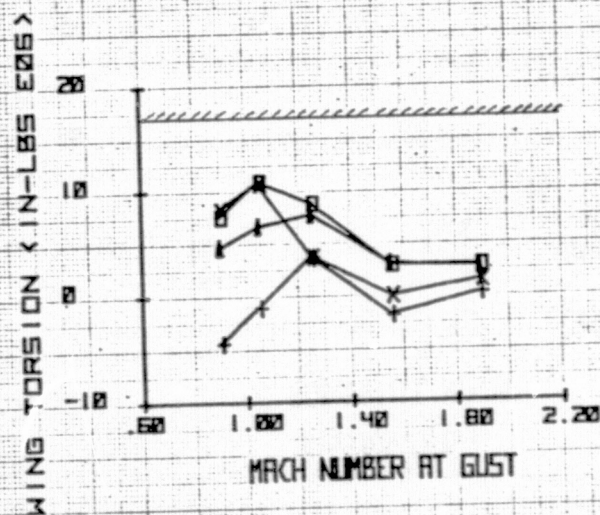
MISSION 3A
95 PERCENTILE WINDS

SYM	PSI
□	75
X	115
+	217
	250



MISSION DFT-1
95 PERCENTILE WINDS

SYM	PSI
□	0
X	75
+	200
	310



NASA-JSC

FIGURE 79.- IMPACT OF WINDS ON LEFT WING ROOT TORSION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

BY L. Austin

PLOT NO.

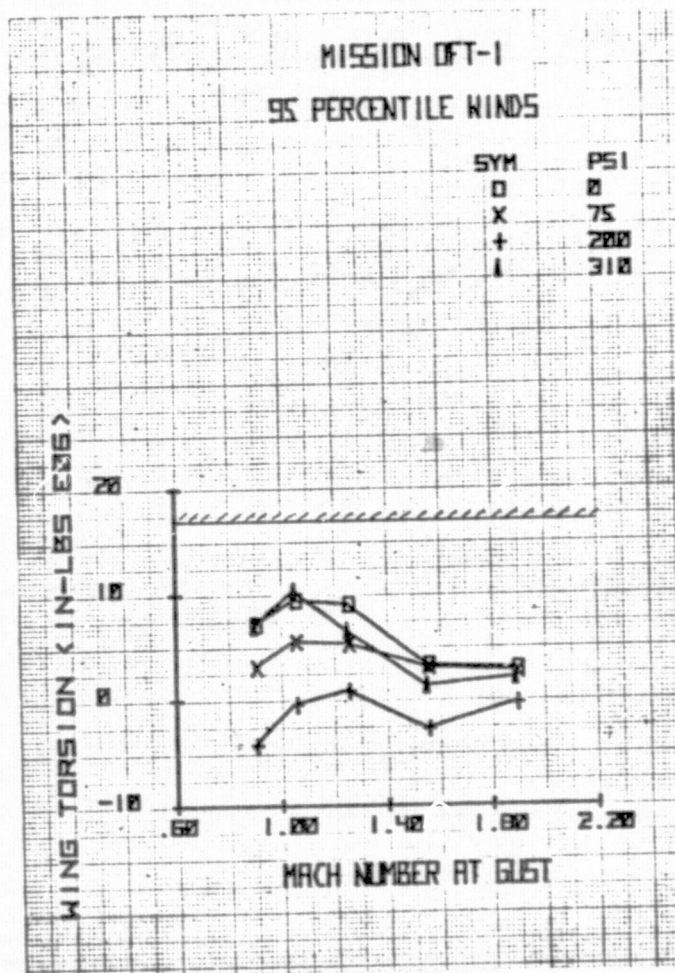
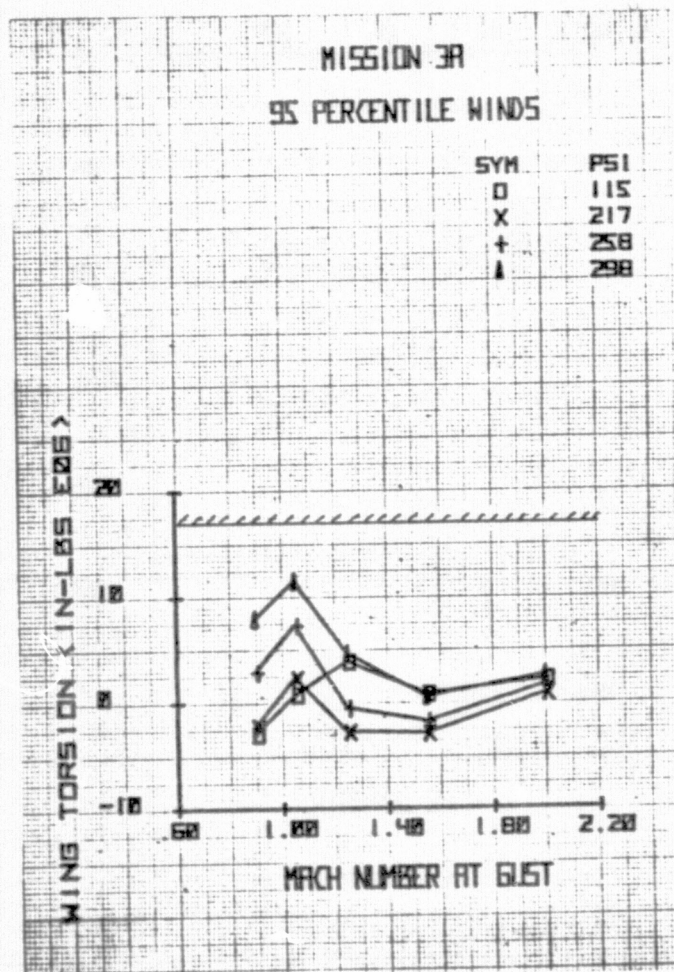


FIGURE 80.- IMPACT OF WINDS ON RIGHT WING SHEAR

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

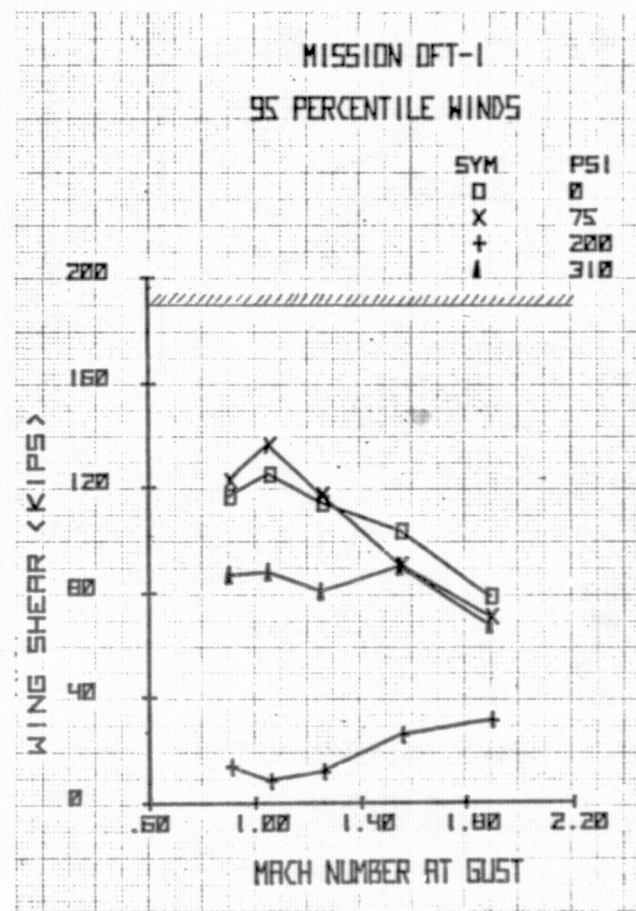
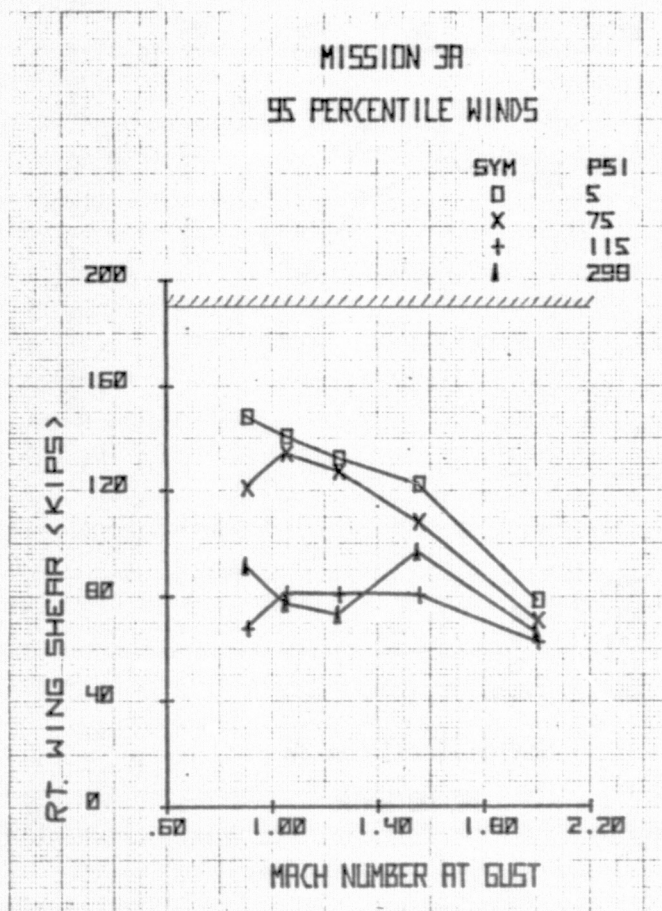


FIGURE 81.- IMPACT OF WINDS ON LEFT WING SHEAR

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE _____

BY L. Austin

PLOT NO. _____

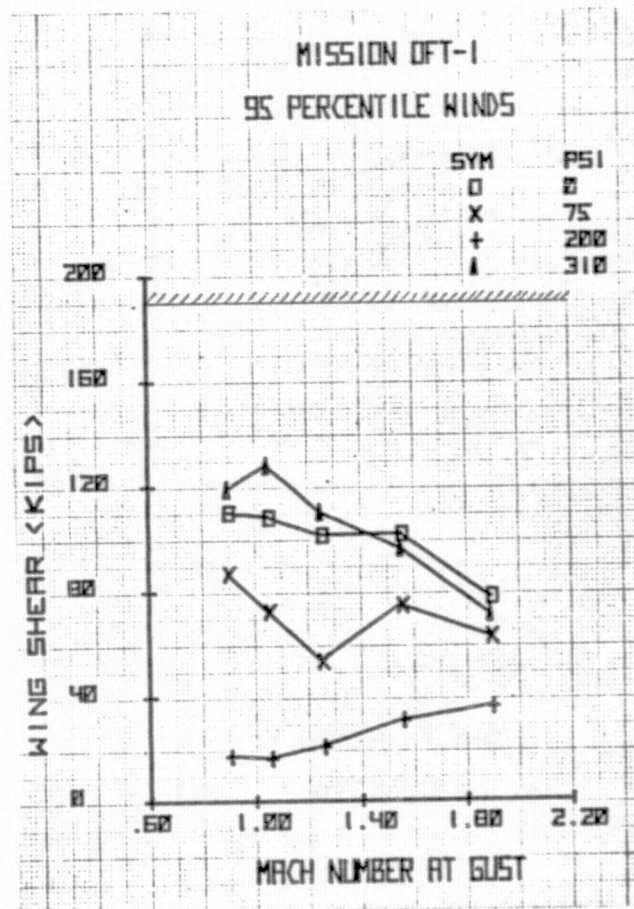
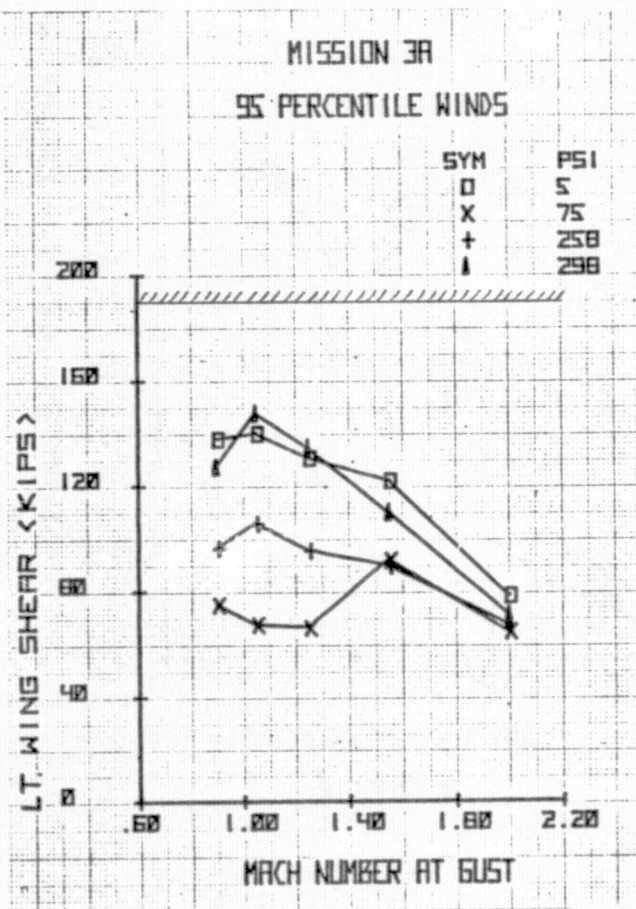
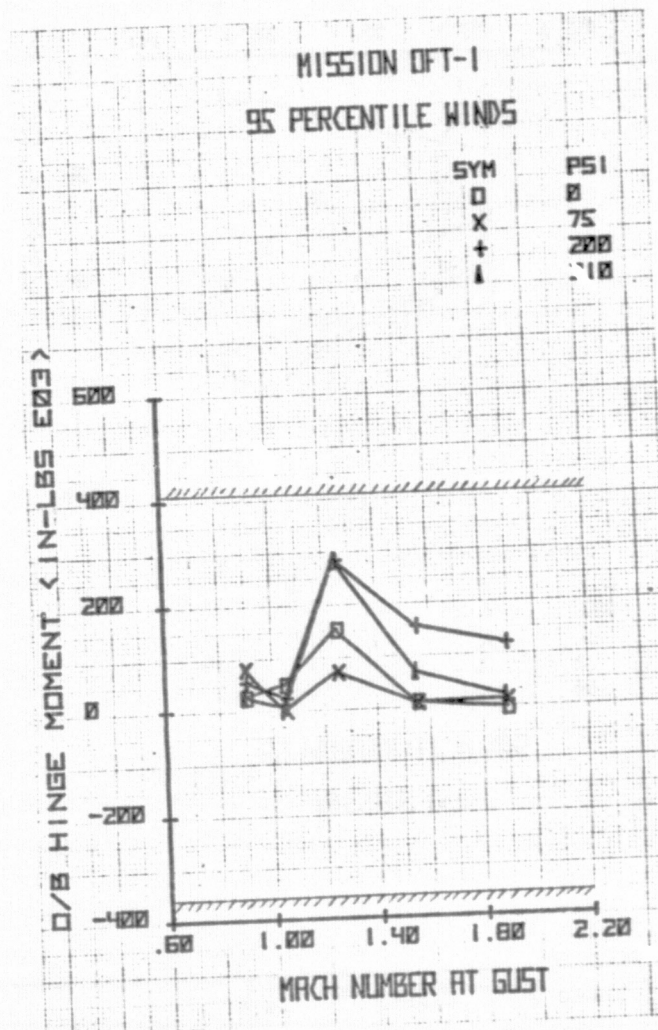
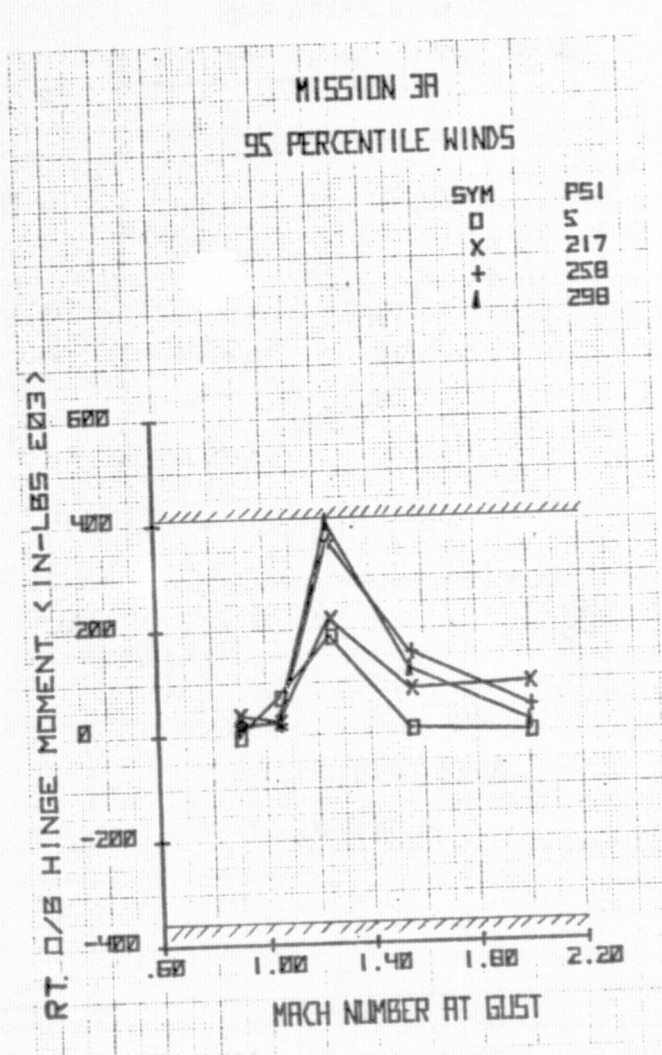


FIGURE 82.- IMPACT OF WINDS ON RIGHT OUTBOARD ELEVON
HINGE MOMENT

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.



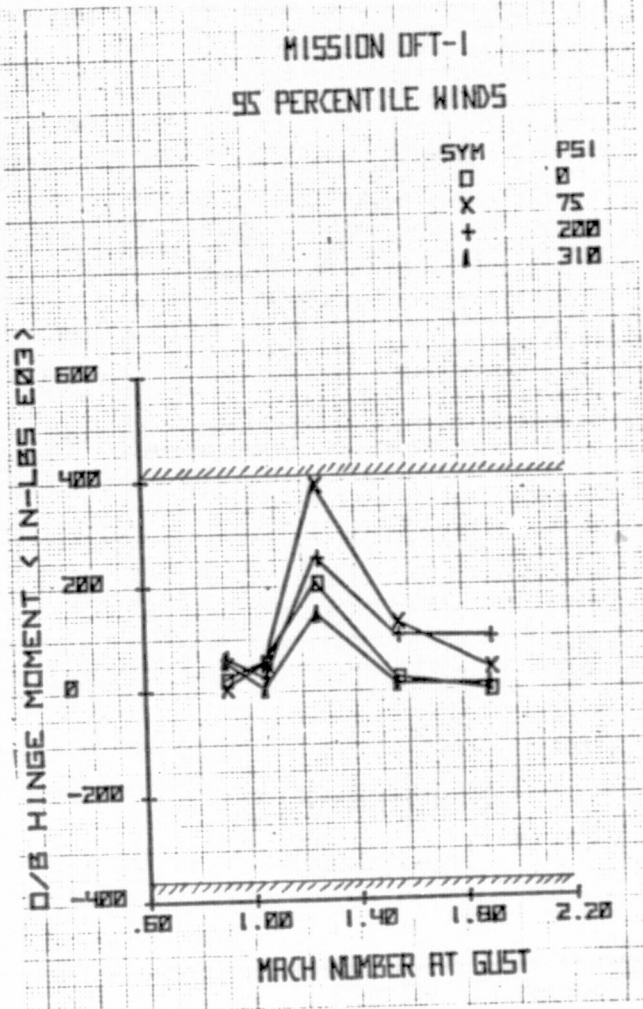
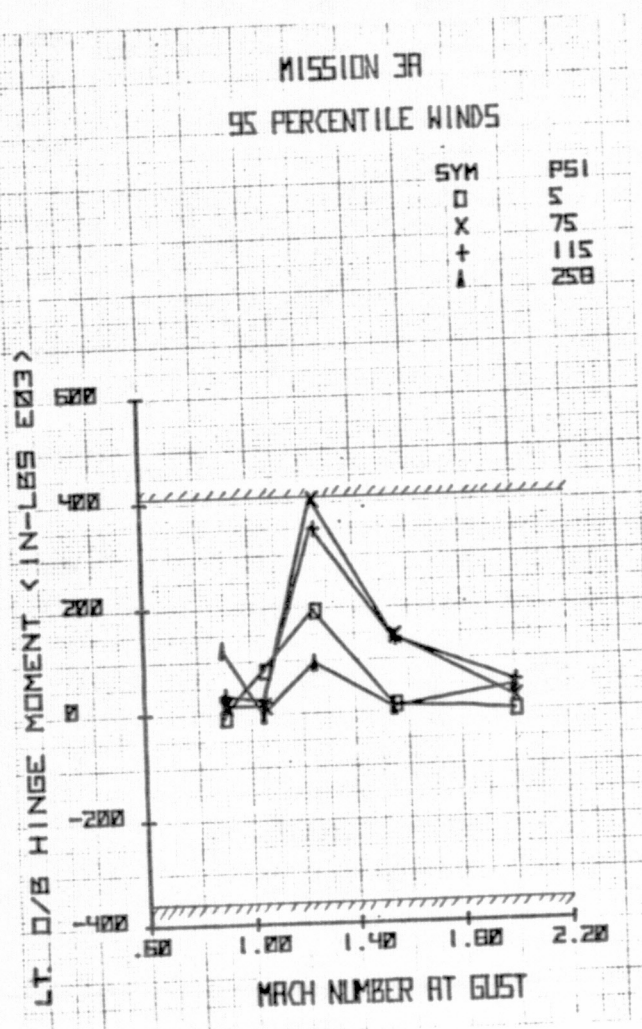
NASA-JSC

FIGURE 83.- IMPACT OF WINDS ON LEFT OUTBOARD ELEVON HINGE MOMENT

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE _____

BY L. Austin PLOT NO. _____



NASA-JSC

FIGURE 84.- IMPACT OF WINDS ON RIGHT INBOARD ELEVON
HINGE MOMENT

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

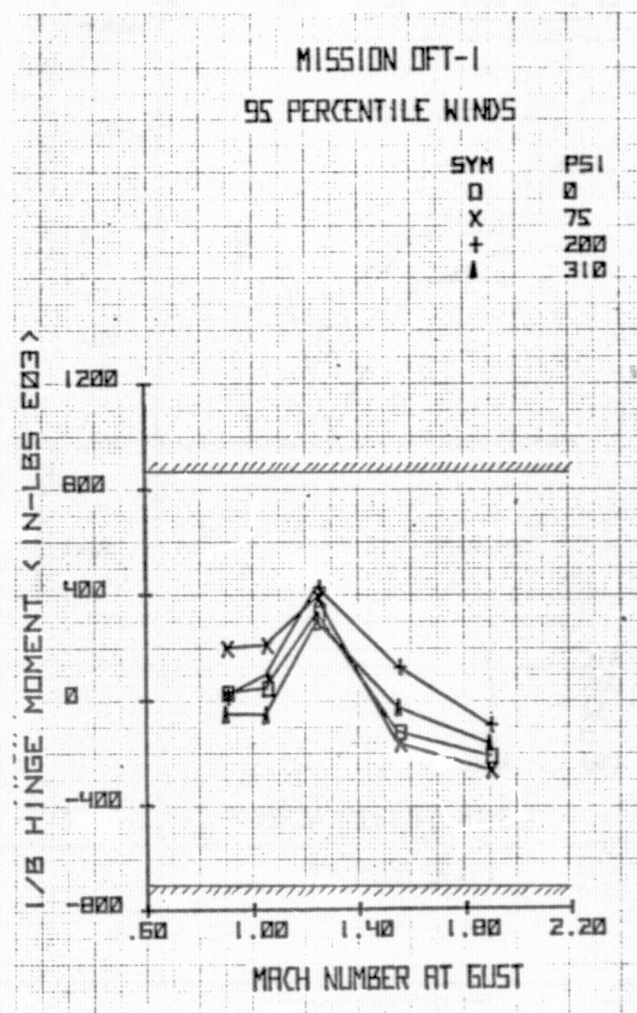
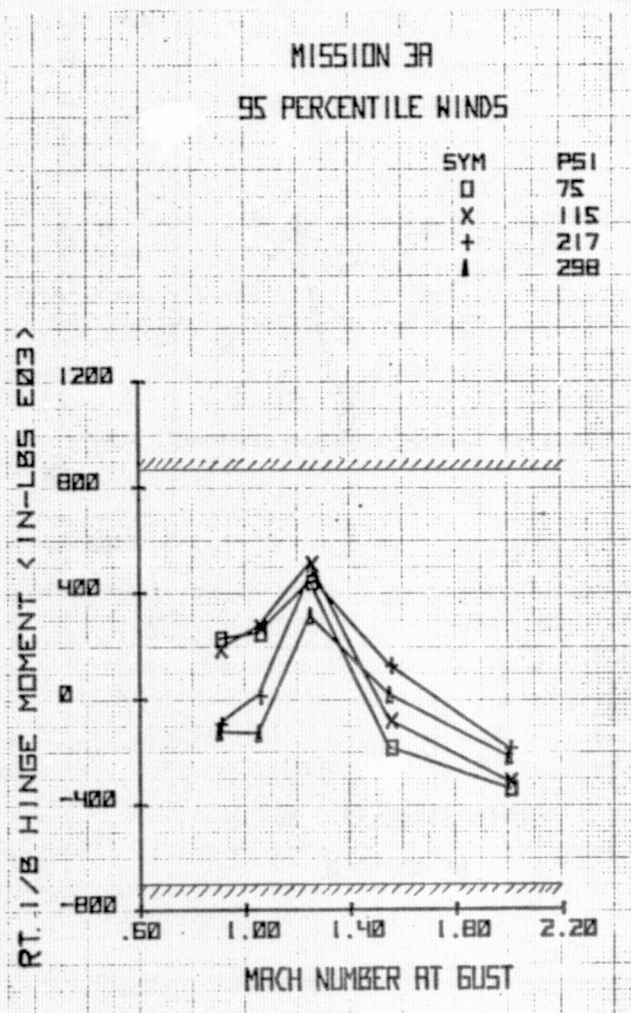


FIGURE 85.- IMPACT OF WINDS ON LEFT INBOARD ELEVON
HINGE MOMENT

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE _____

BY L. Austin PLOT NO. _____

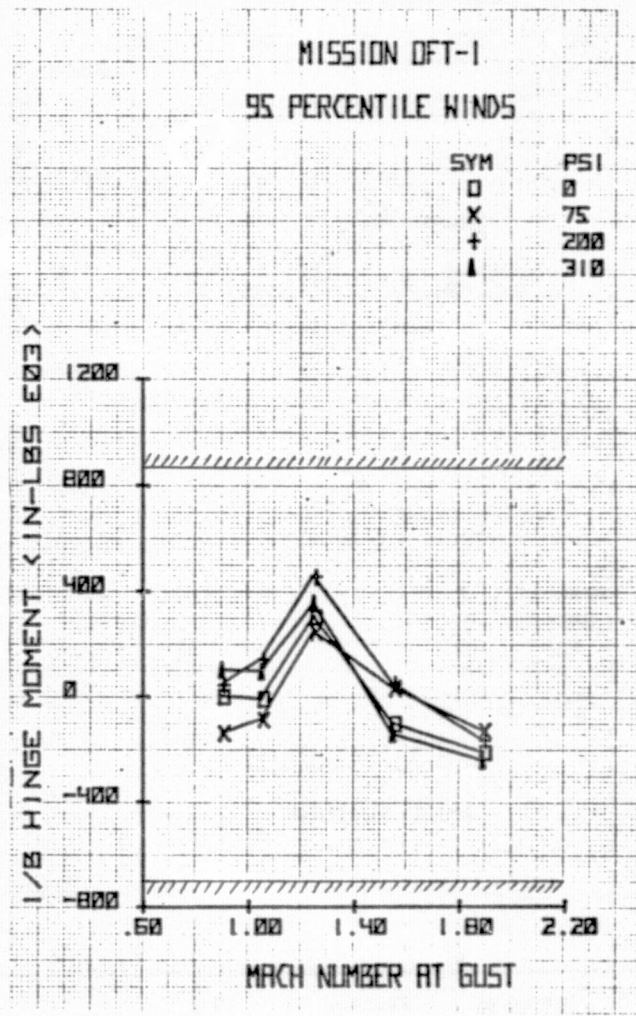
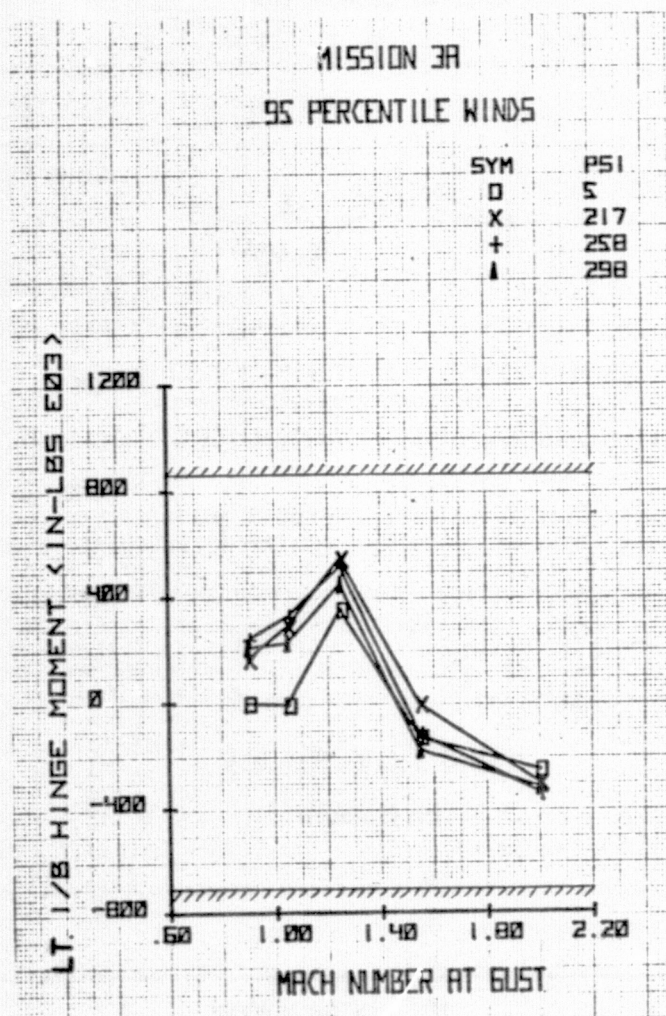


FIGURE 86.- IMPACT OF WINDS ON FORWARD Z ORBITER/ET
ATTACH POINT/FTO1

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

BY L. Austin

PLOT NO.

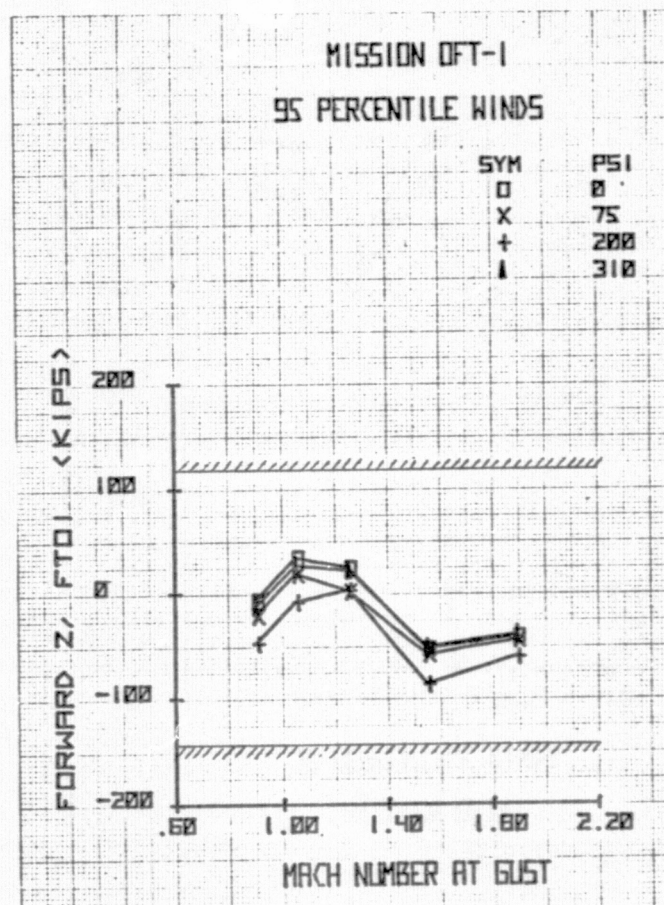
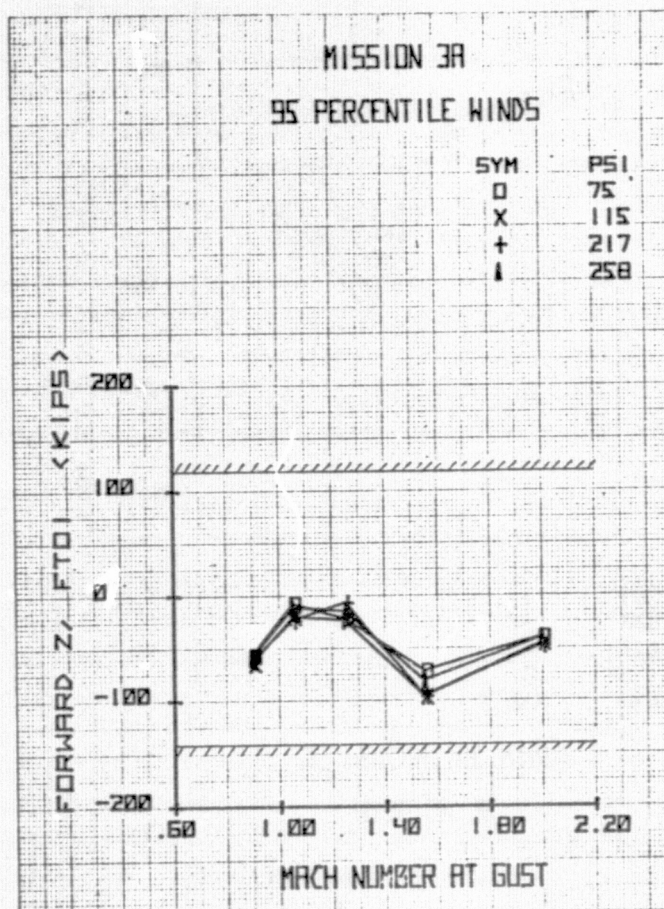


FIGURE 87.- IMPACT OF WINDS ON FORWARD Y ORBITER/ET
ATTACH POINT/FT02

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

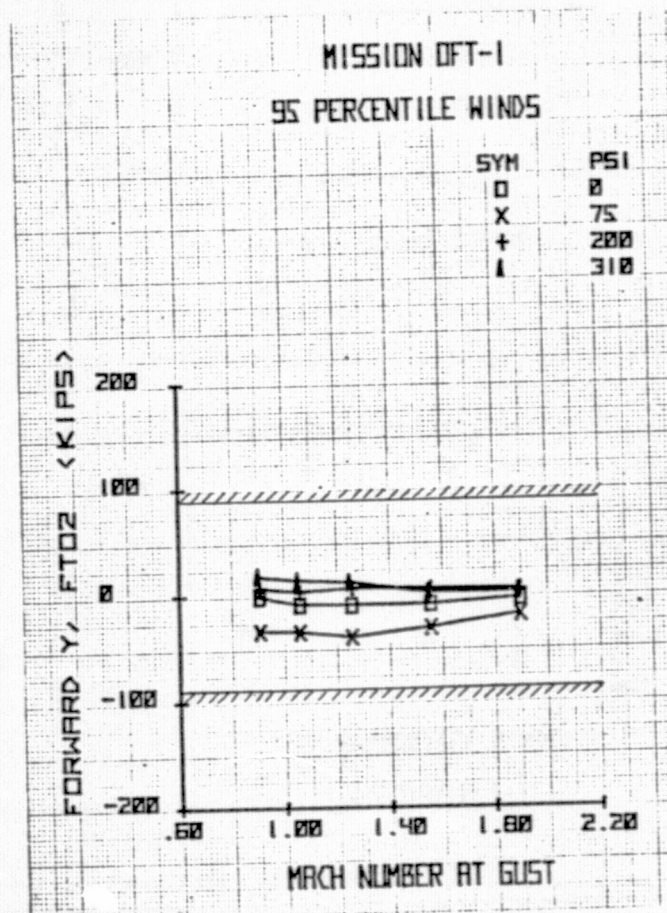
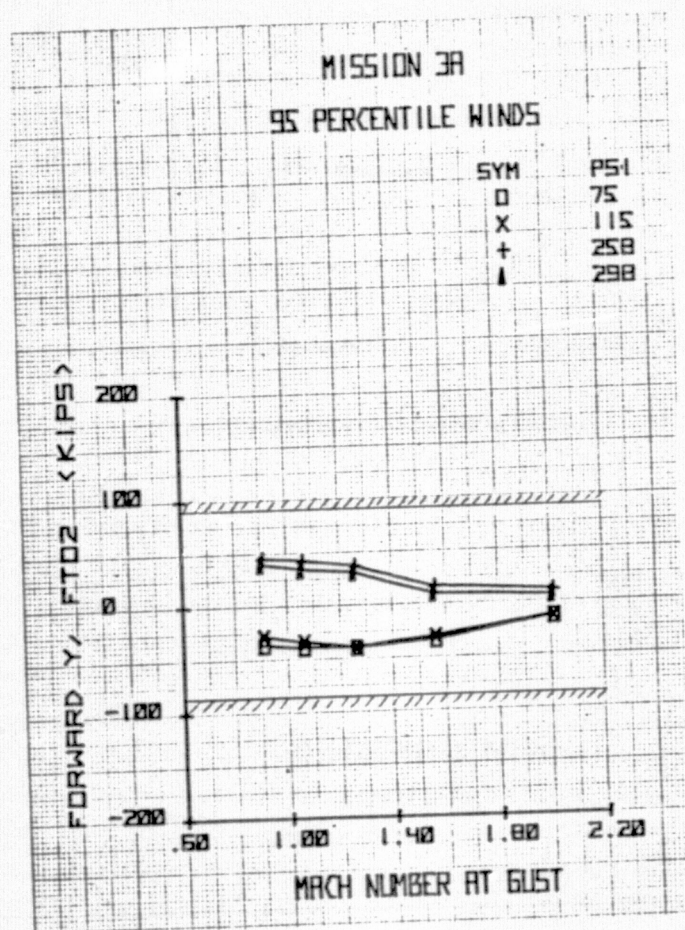


FIGURE 88.- IMPACT OF WINDS ON AFT LEFT Z ORBITER/ET ATTACH POINT/FT03

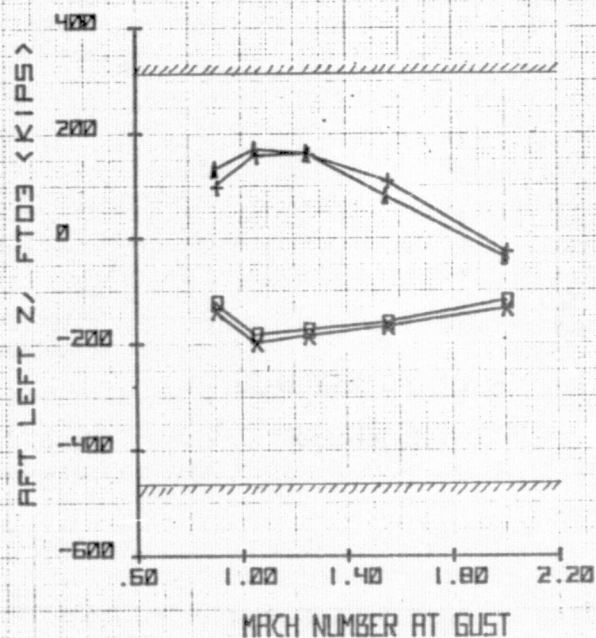
ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE _____

BY L. Austin PLOT NO. _____

MISSION 3A
95 PERCENTILE WINDS

SYM	PSI
□	75
X	115
+	258
▲	298



MISSION DFT-1
95 PERCENTILE WINDS

SYM	PSI
□	0
X	75
+	200
▲	310

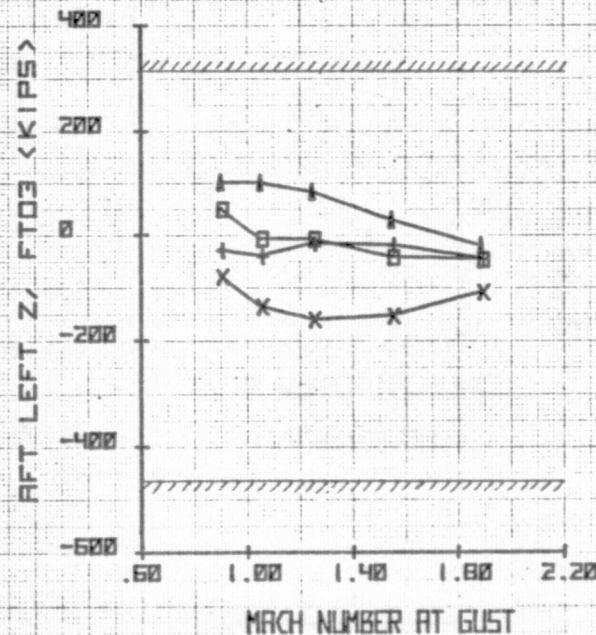


FIGURE 89.- IMPACT OF WINDS ON AFT RIGHT Z ORBITER/ET
ATTACH POINT/FT04

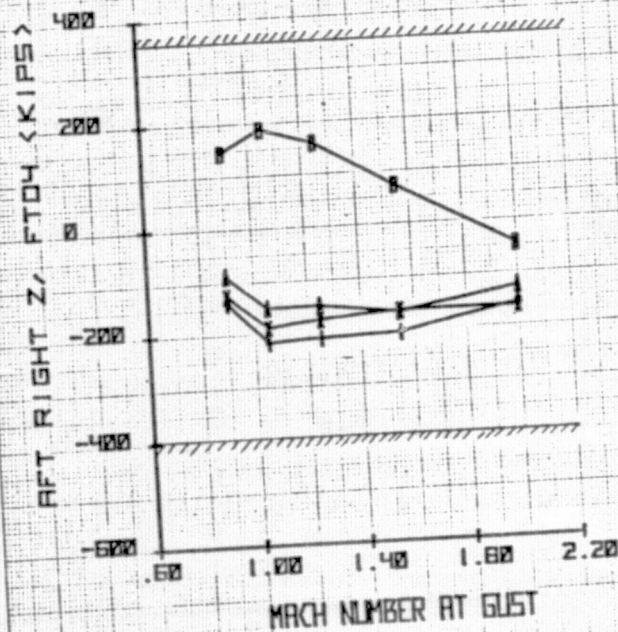
ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

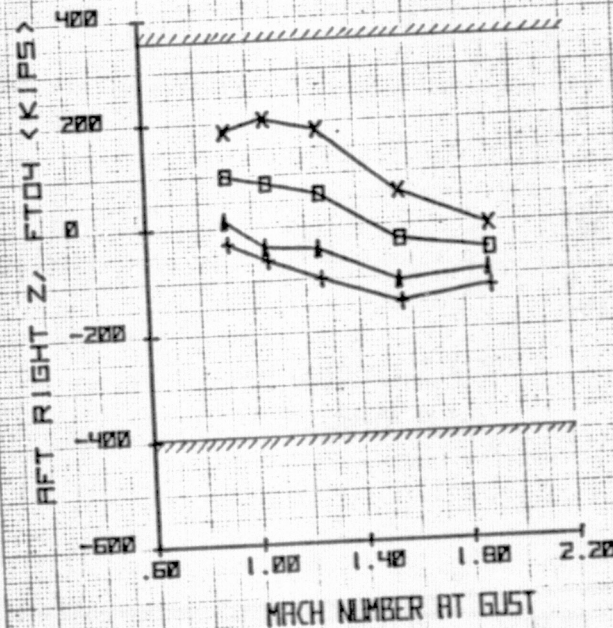
MISSION 3A
95 PERCENTILE WINDS

SYM	PSI
□	75
X	217
+	258
↓	298



MISSION DFT-1
95 PERCENTILE WINDS

SYM	PSI
□	75
X	217
+	258
↓	310



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FIGURE 90.- IMPACT OF WINDS ON AFT RIGHT Y ORBITER/ET
ATTACH POINT/FT06

ENGINEERING ANALYSIS DIVISION/EX

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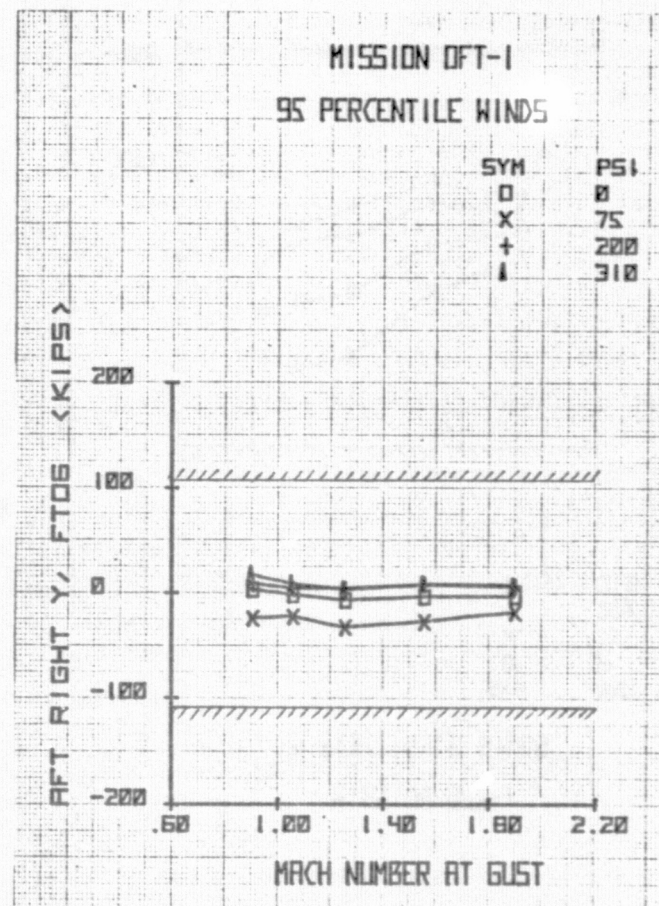
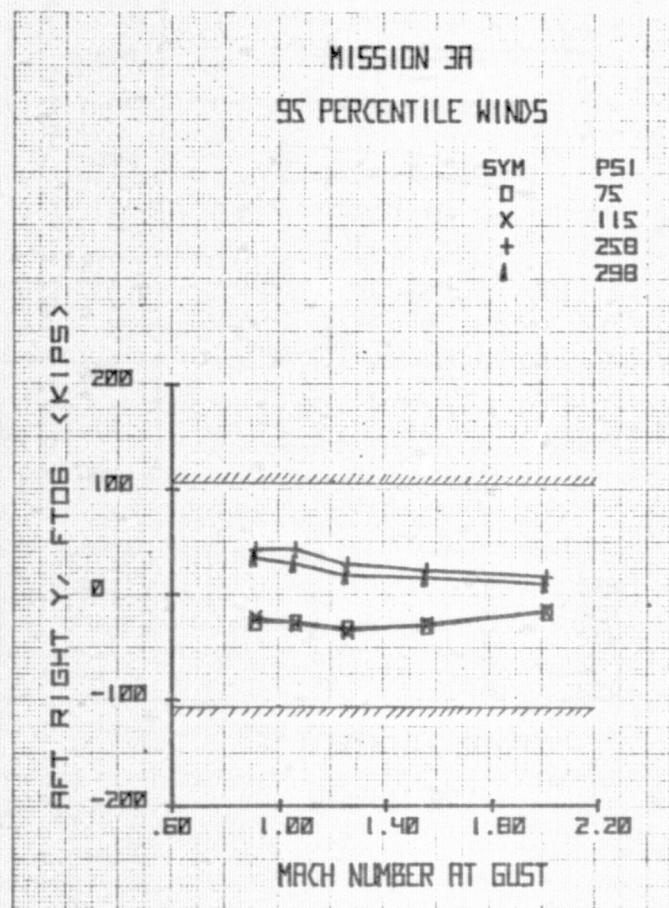


FIGURE 91.- IMPACT OF WINDS ON AFT LEFT X ORBITER/ET
ATTACH POINT/FT07

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

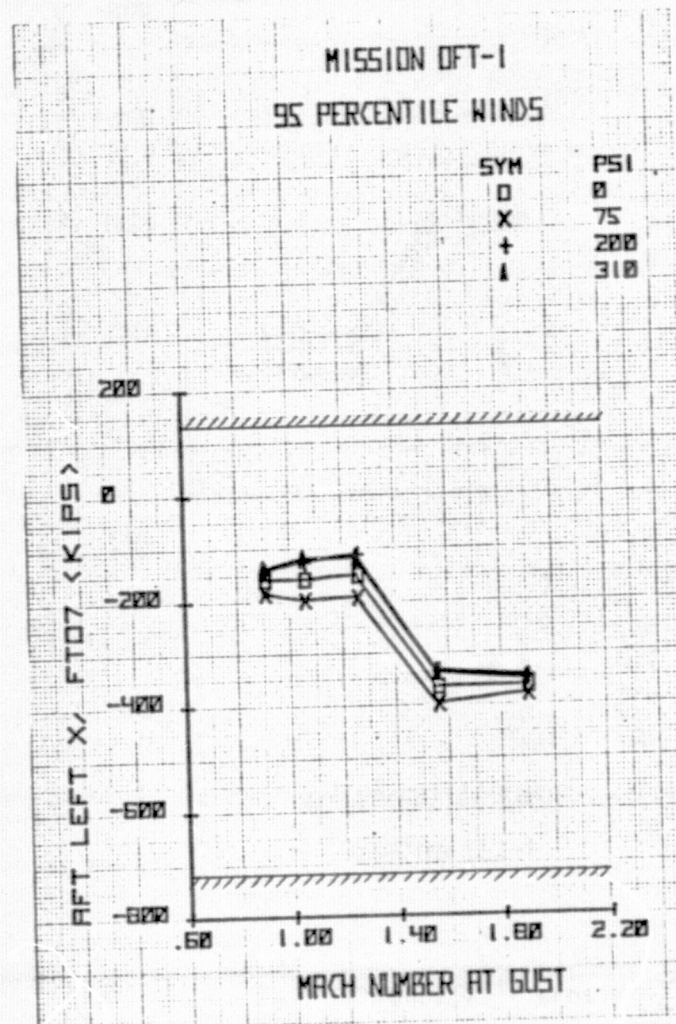
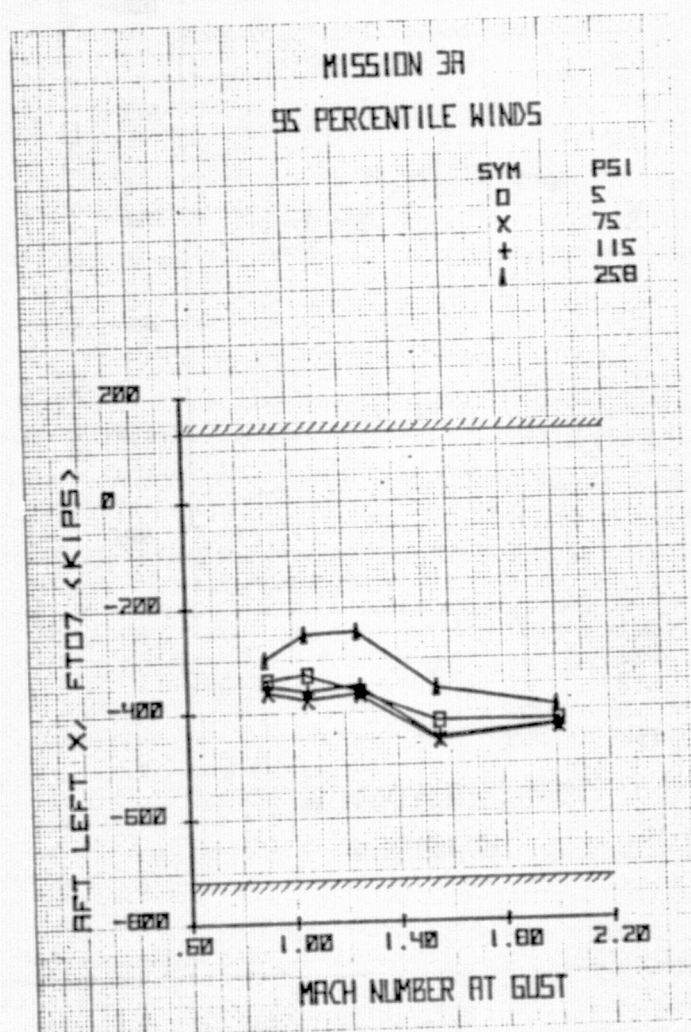


FIGURE 92.- IMPACT OF WINDS ON AFT RIGHT X ORBITER/ET
ATTACH POINT/FT08

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE _____

BY L. Austin PLOT NO. _____

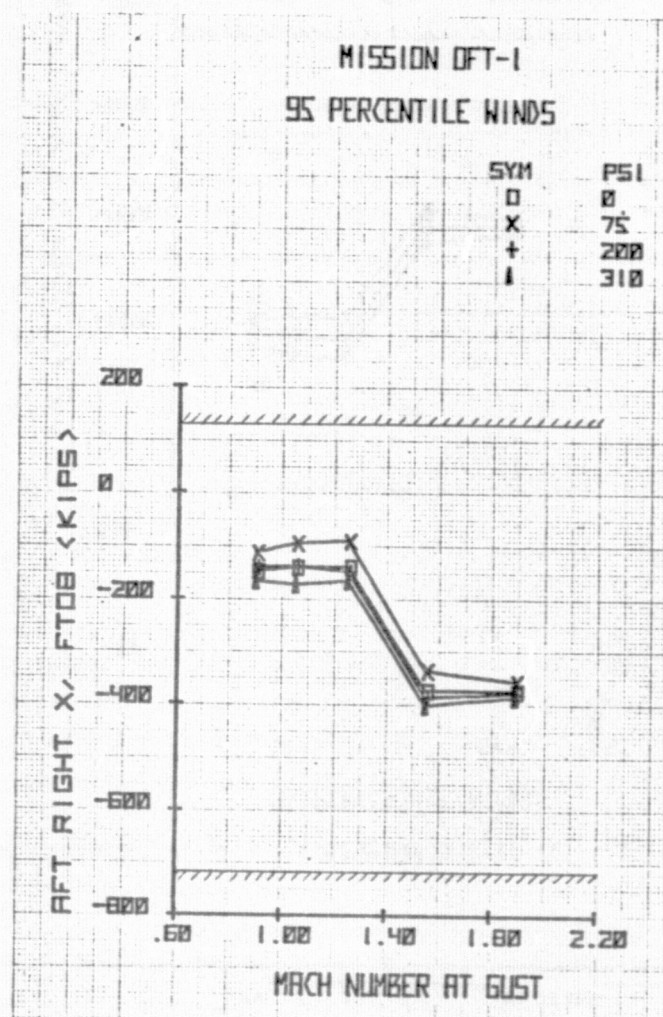
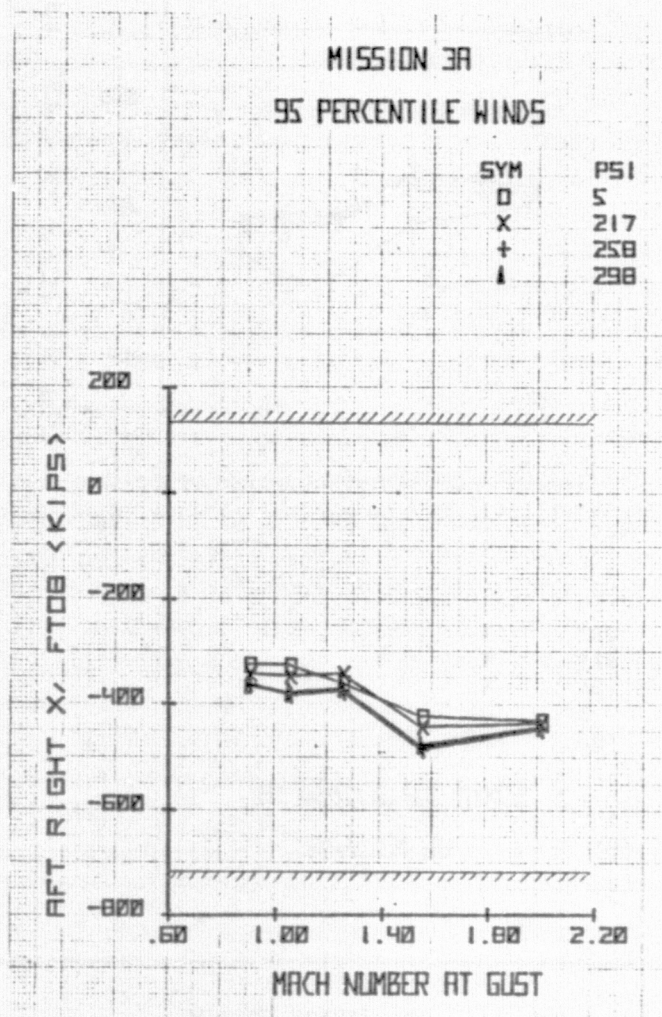
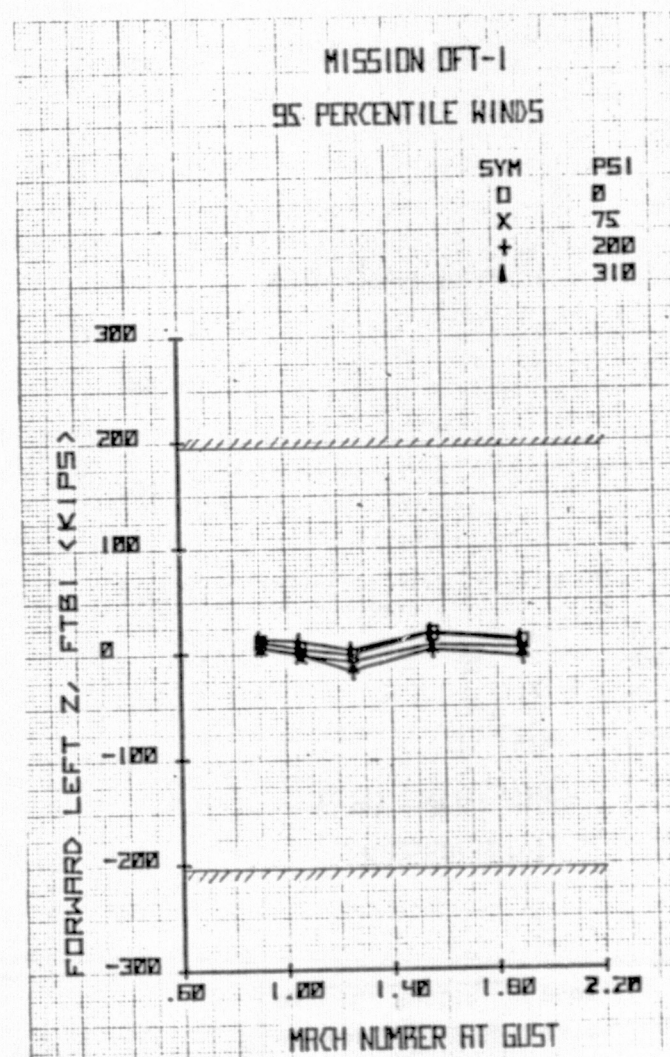
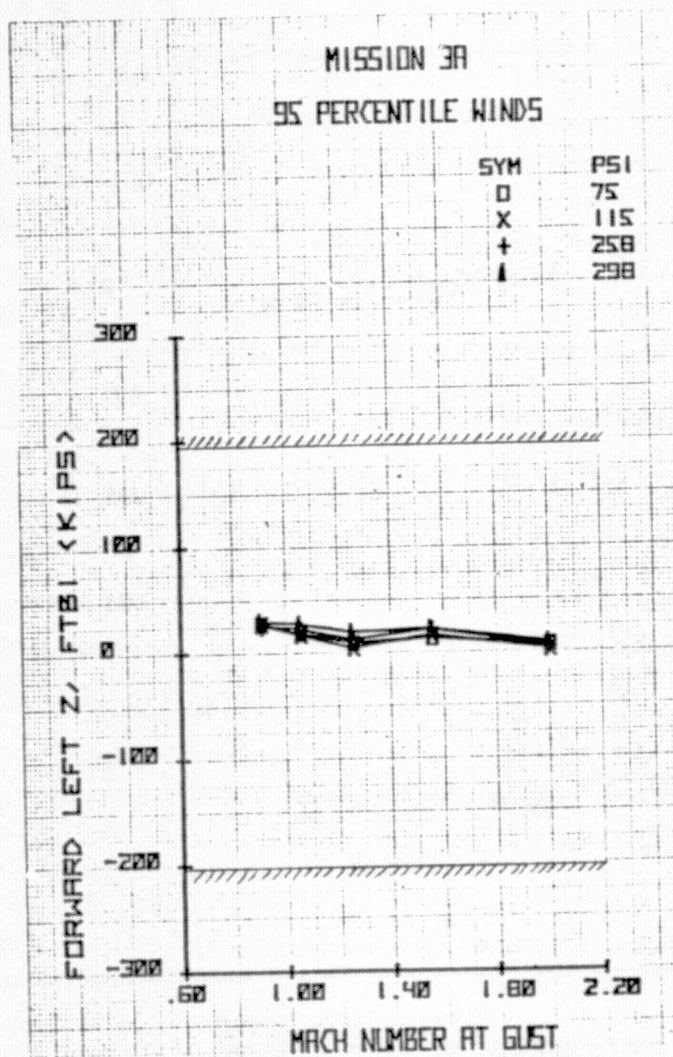


FIGURE 93.- IMPACT OF WINDS ON FORWARD LEFT Z SRB/ET
ATTACH POINT/FTB1

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.



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FIGURE 94.- IMPACT OF WINDS ON FORWARD RIGHT Z SRB/ET
ATTACH POINT/FTB2

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

BY L. Austin

PLOT NO.

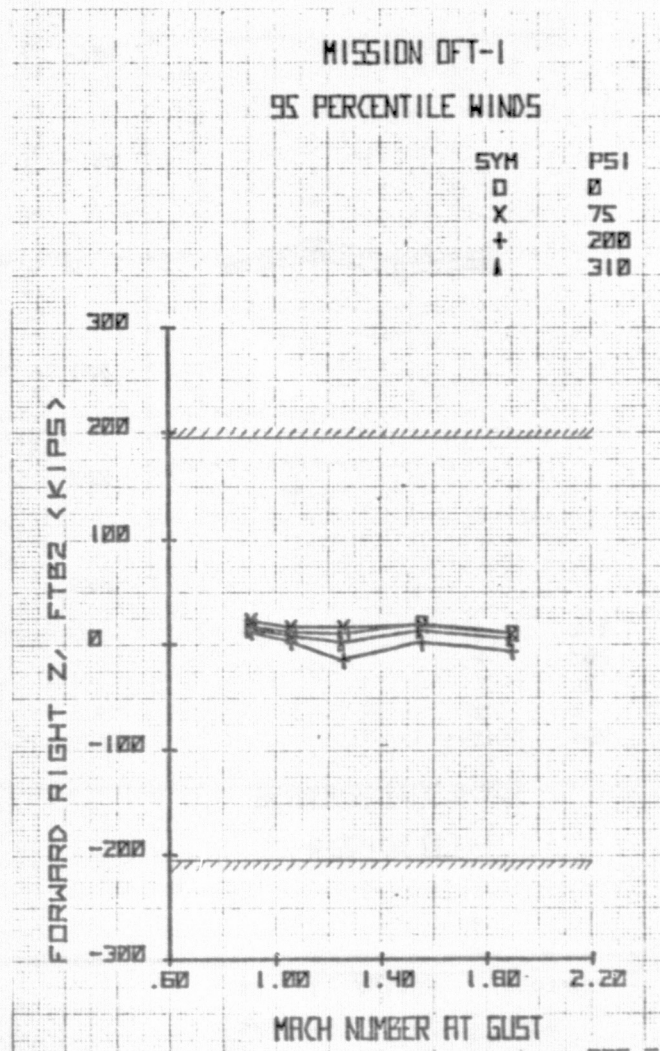
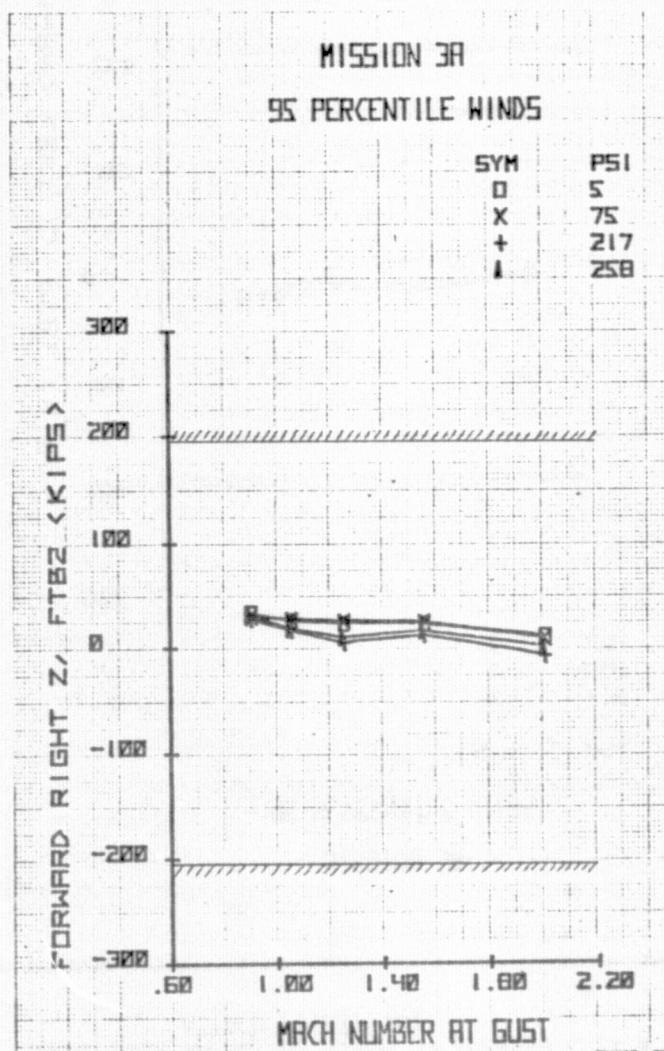


FIGURE 95.- IMPACT OF WINDS ON FORWARD LEFT Y SRB/ET
ATTACH POINT/FTB3

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

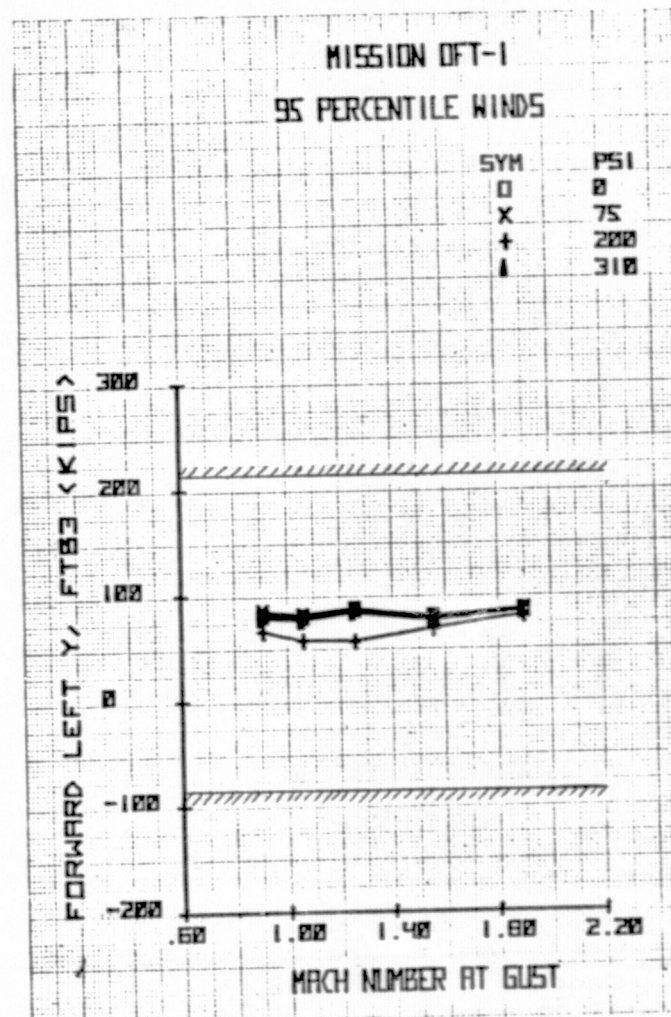
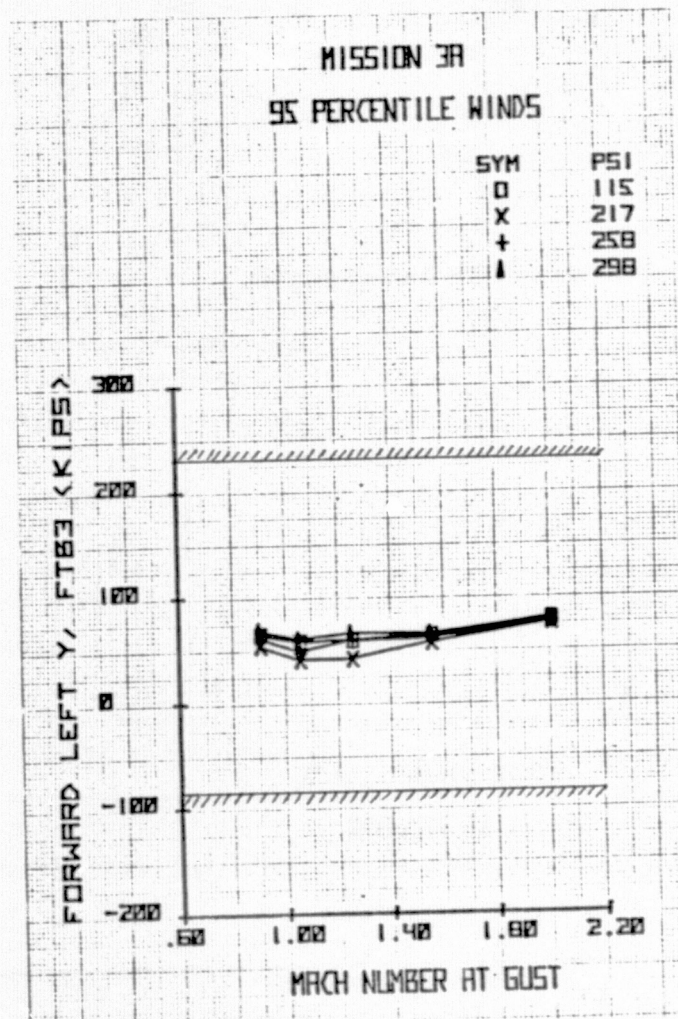


FIGURE 96.- IMPACT OF WINDS ON FORWARD RIGHT Y SRB/ET
ATTACH POINT/FTB4

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE _____

BY L. Austin PLOT NO. _____

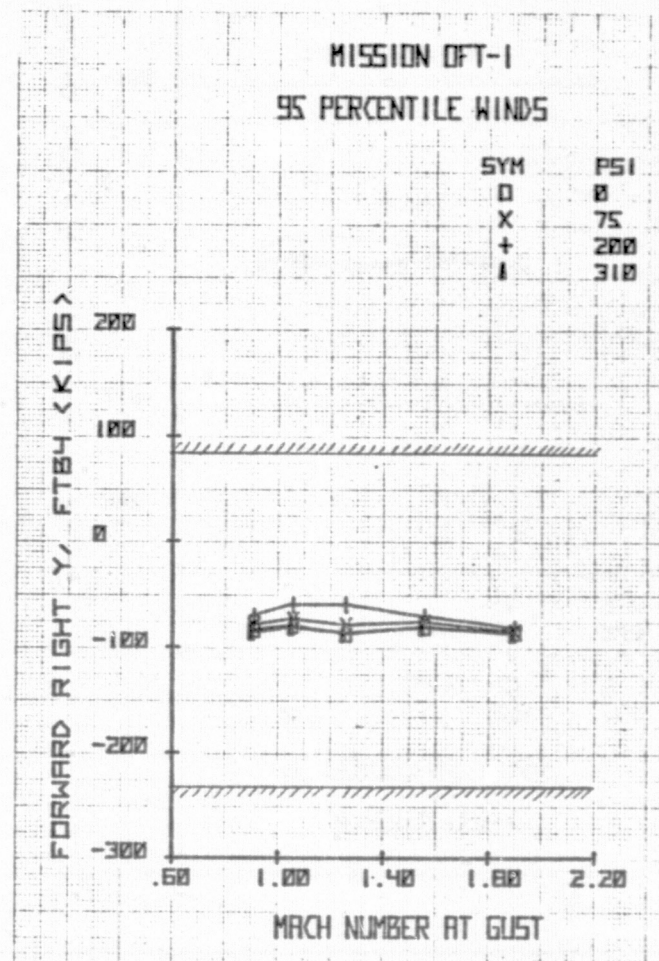
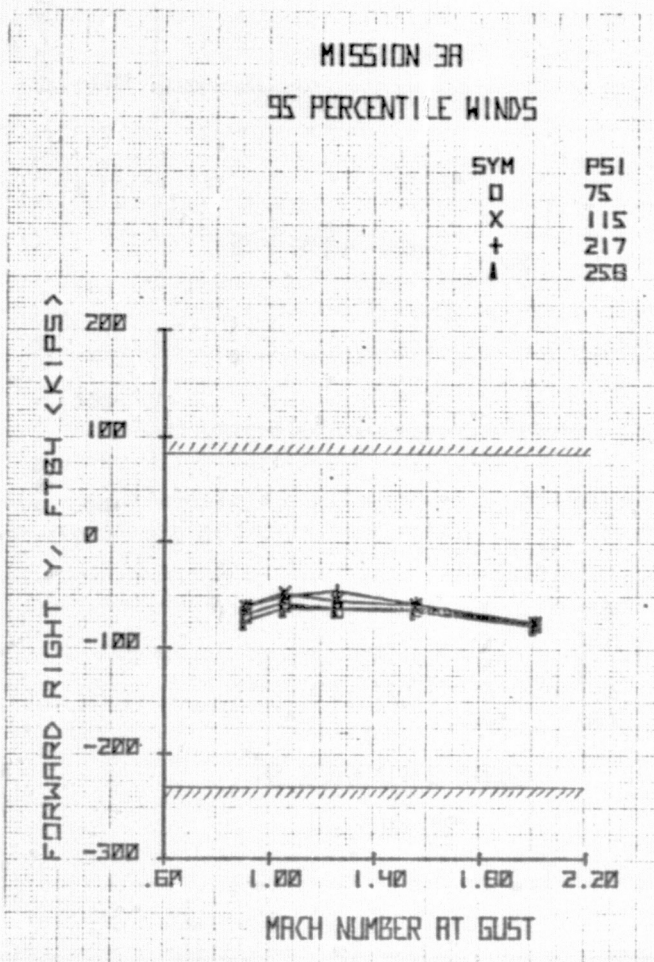


FIGURE 97.- IMPACT OF WINDS ON FORWARD LEFT X SRB/ET
ATTACH POINT/FTB5

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE _____
BY L. Austin PLOT NO. _____

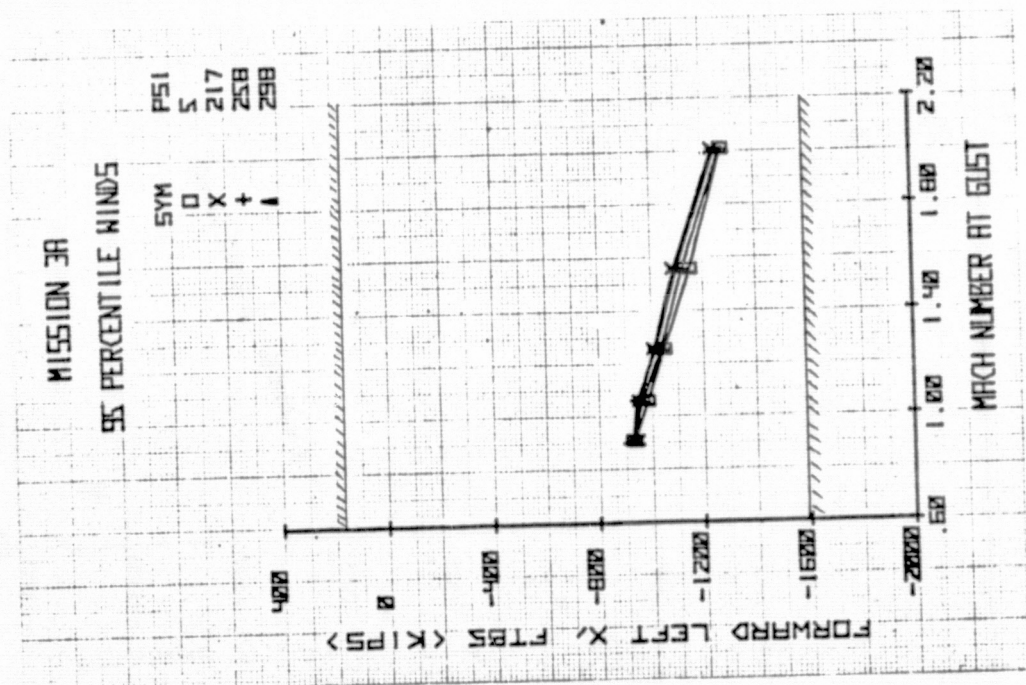
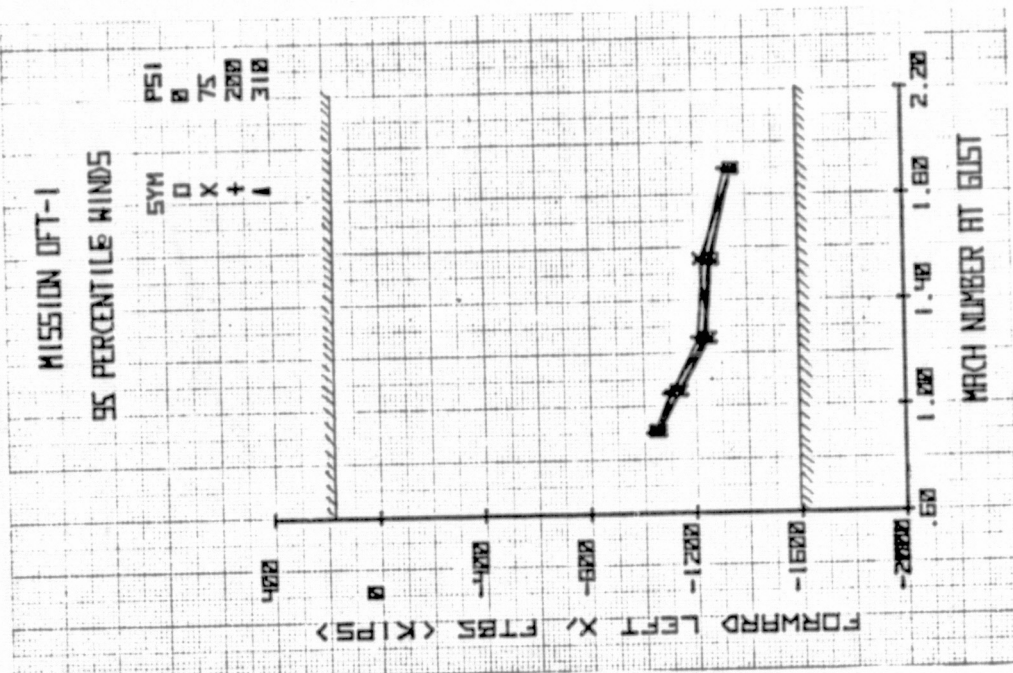


FIGURE 98.- IMPACT OF WINDS ON FORWARD RIGHT X SRB/ET
ATTACH POINT/FTB6

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

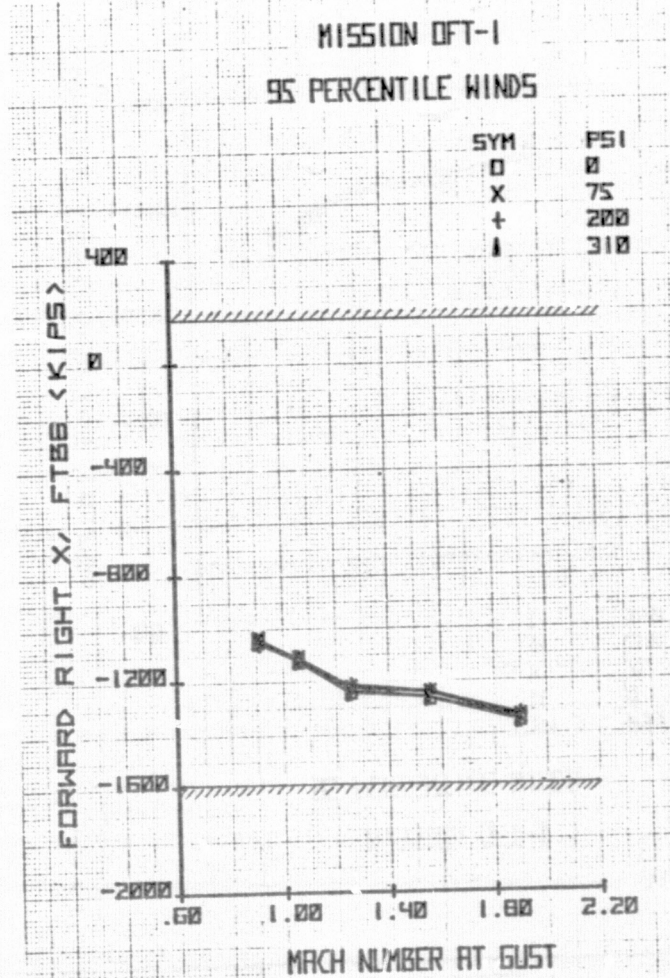
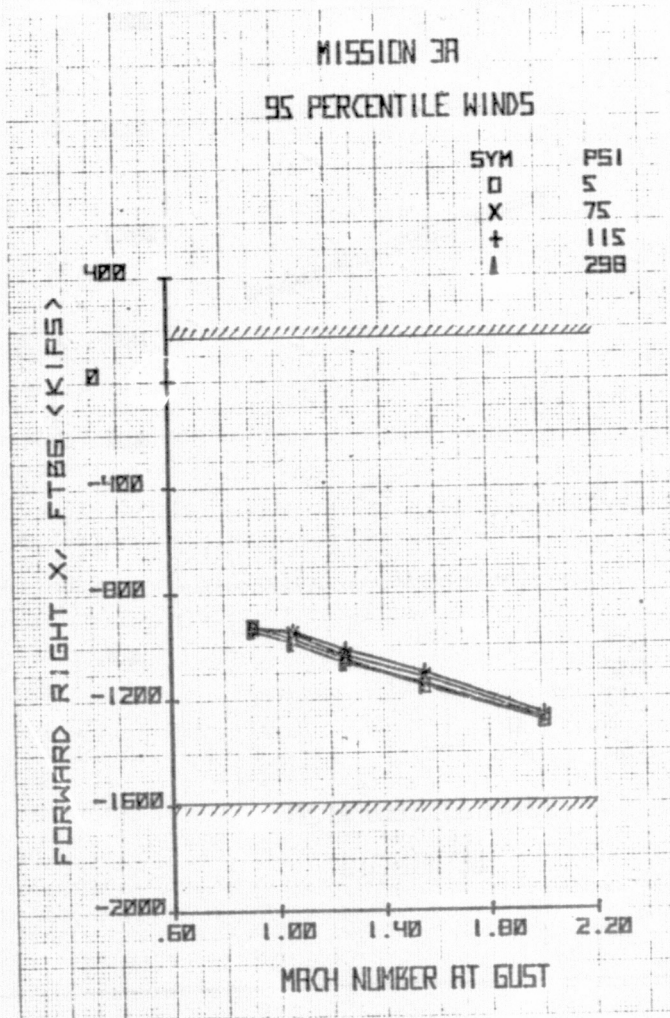


FIGURE 99.- IMPACT OF WINDS ON 3FT LEFT Z SRB/ET
ATTACH POINT/FTB7

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE _____

BY L. Austin

PLOT NO. _____

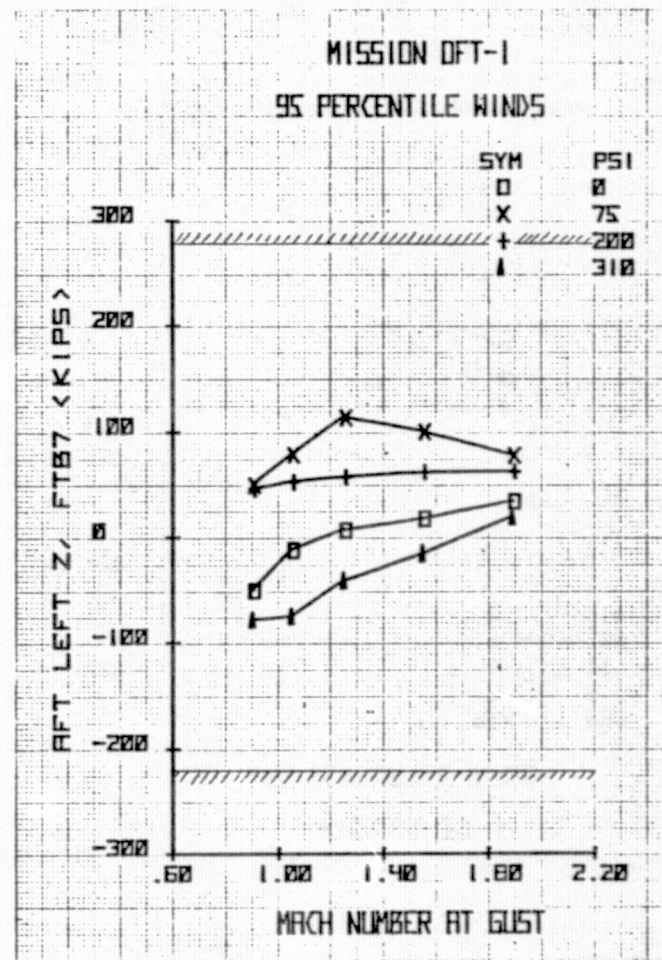
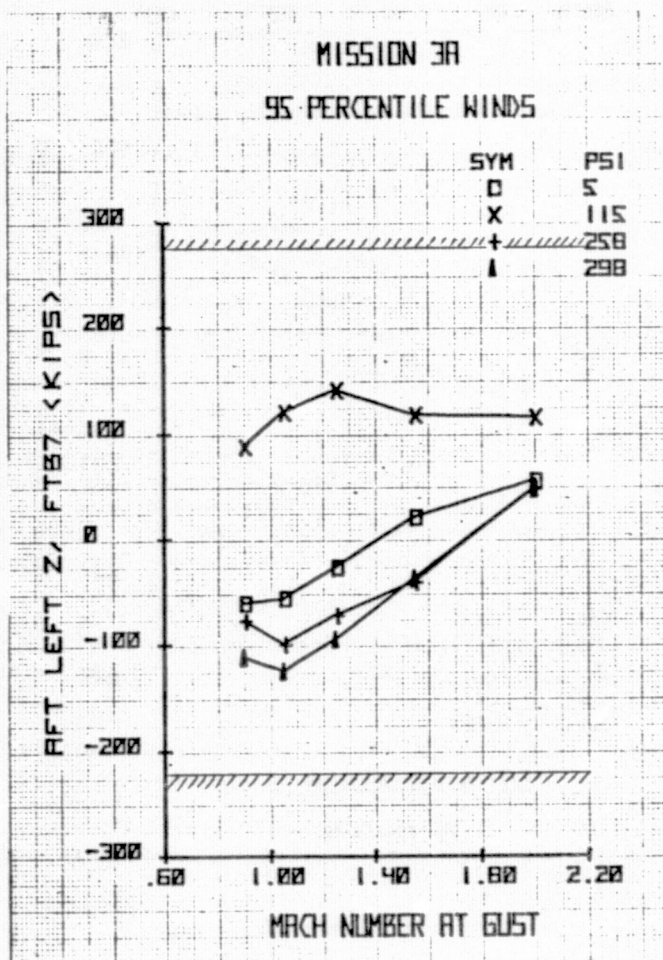


FIGURE 100.- IMPACT OF WINDS ON AFT RIGHT Σ SRB/ET
ATTACH POINT/FTB8

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

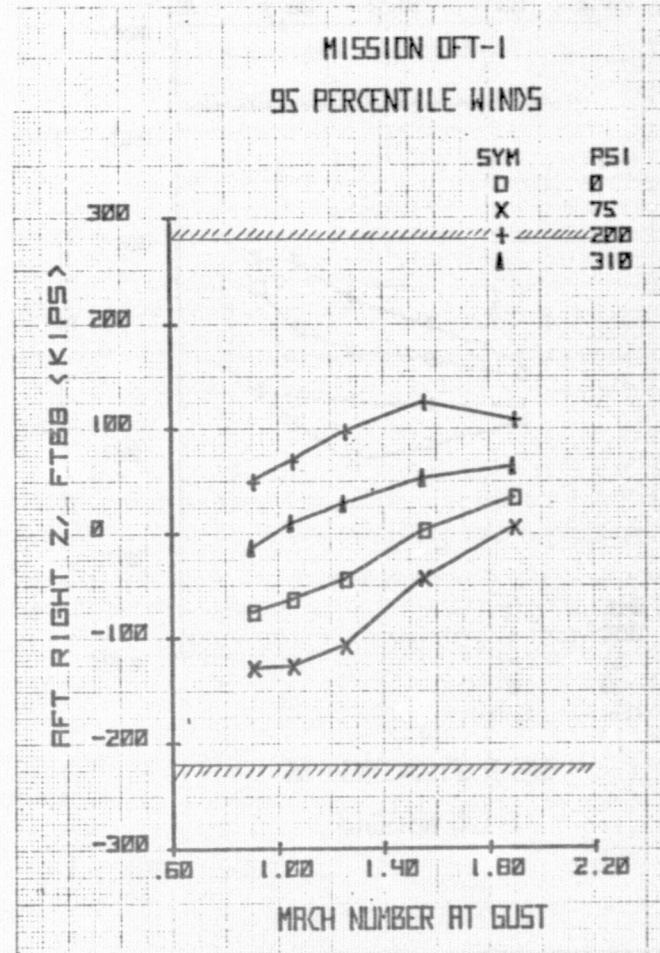
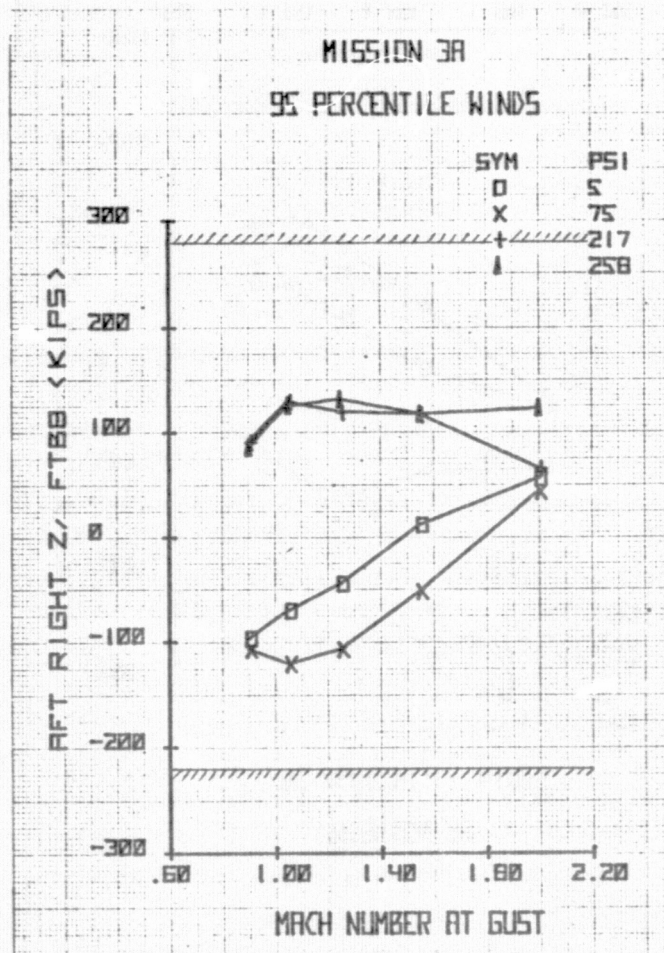


FIGURE 101.- IMPACT OF WINDS ON AFT LEFT Y SRB/ET
ATTACH POINT/FTB9

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

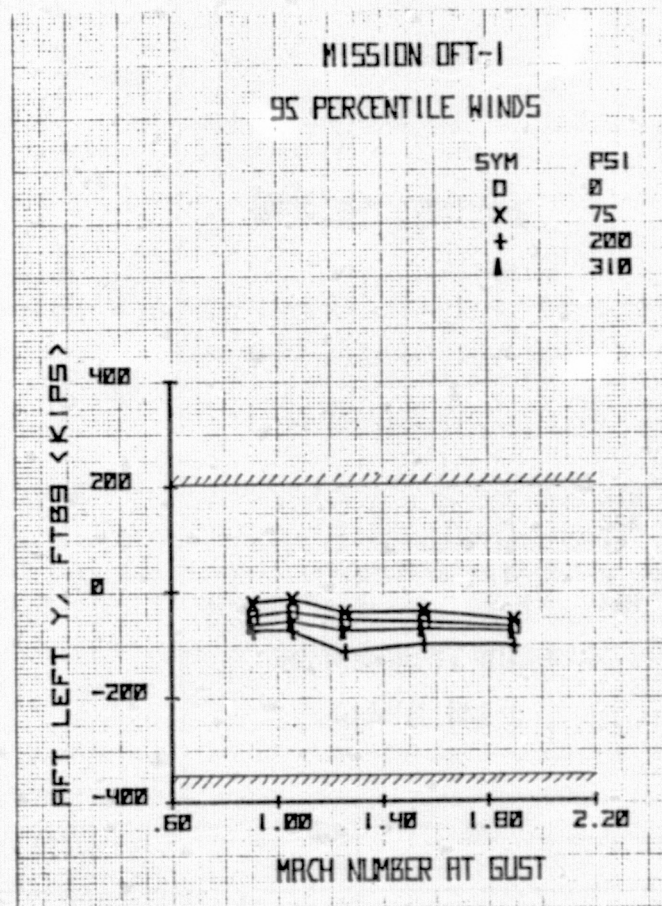
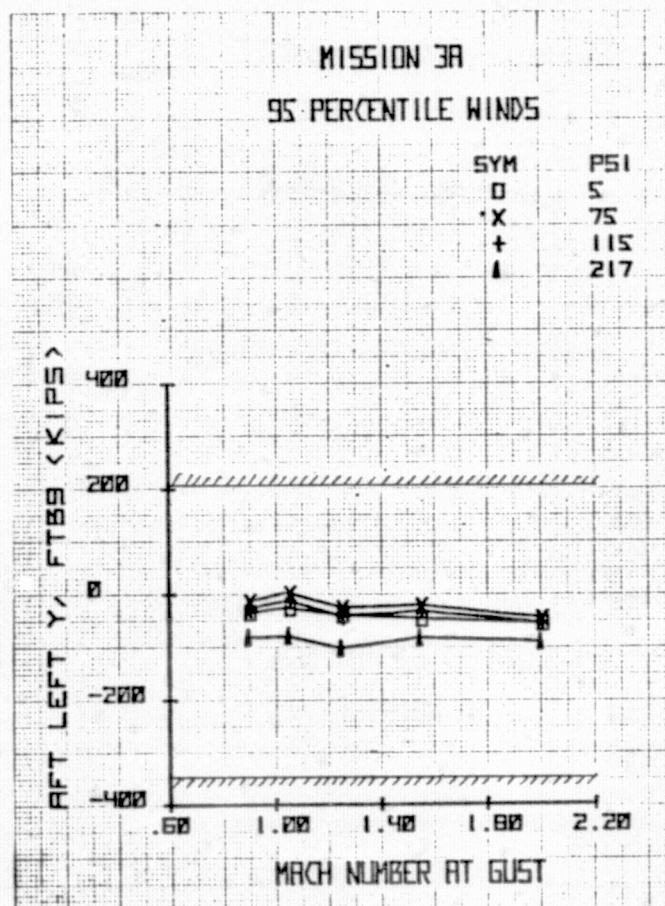


FIGURE 102.- IMPACT OF WINDS ON AFT RIGHT Y SRB/ET
ATTACH POINT/FTB10

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

BY L. Austin

PLOT NO.

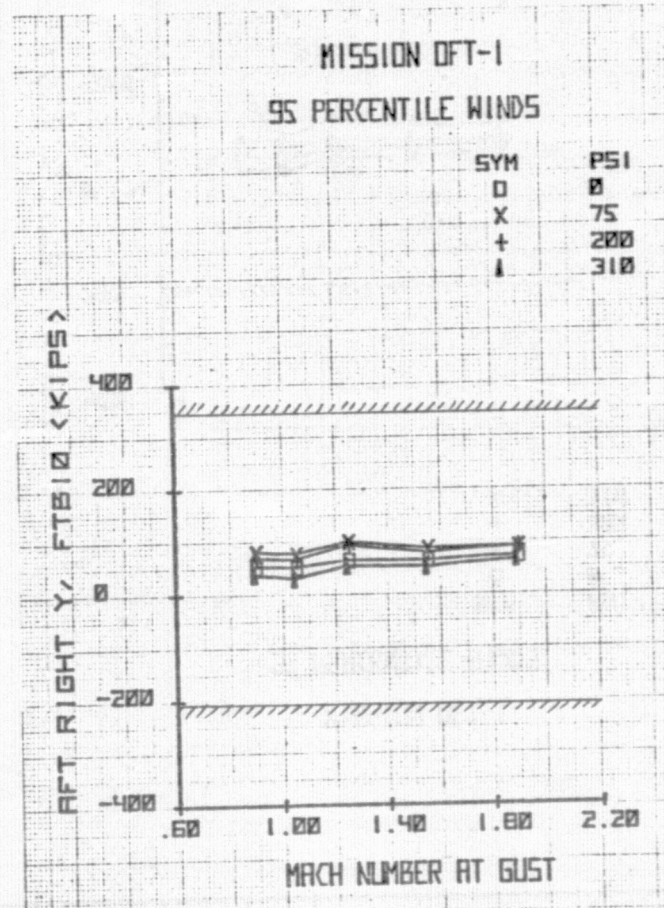
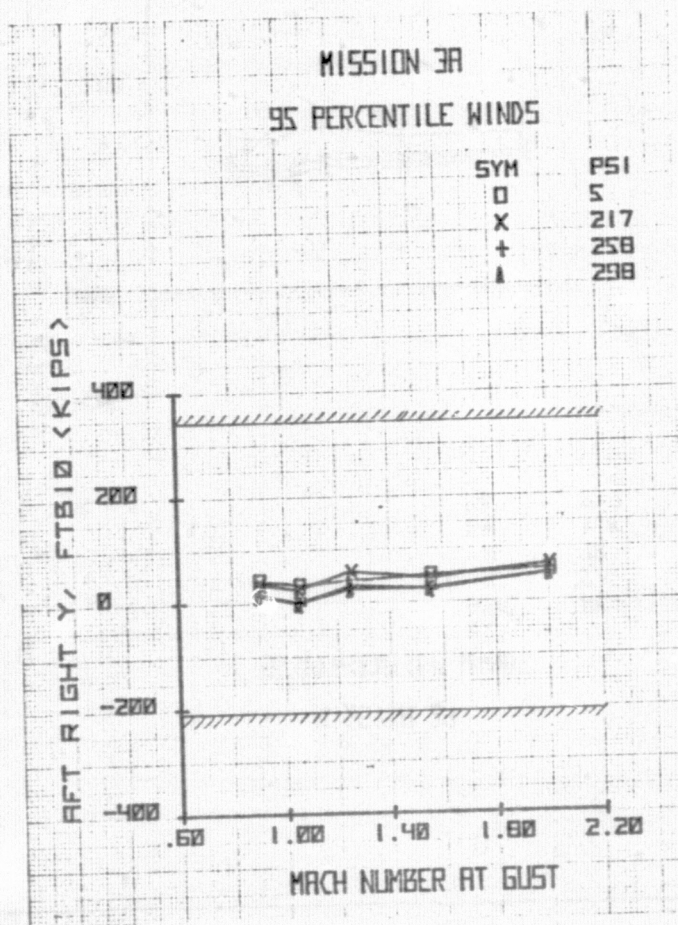


FIGURE 103.- IMPACT OF WINDS ON LEFT SRB
MOMENT/MTBI

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

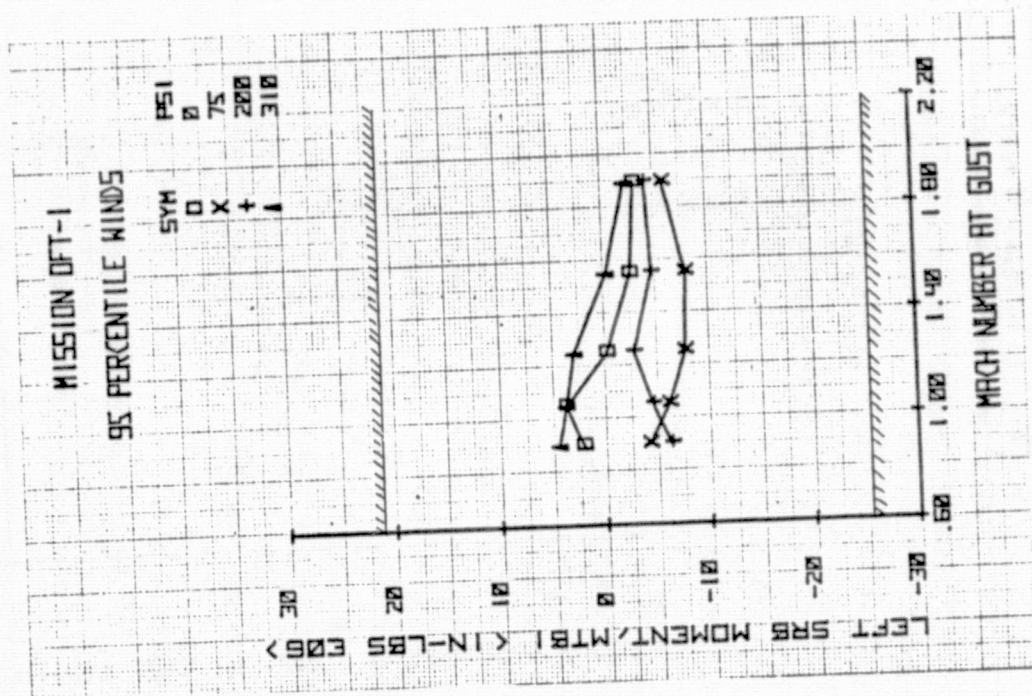
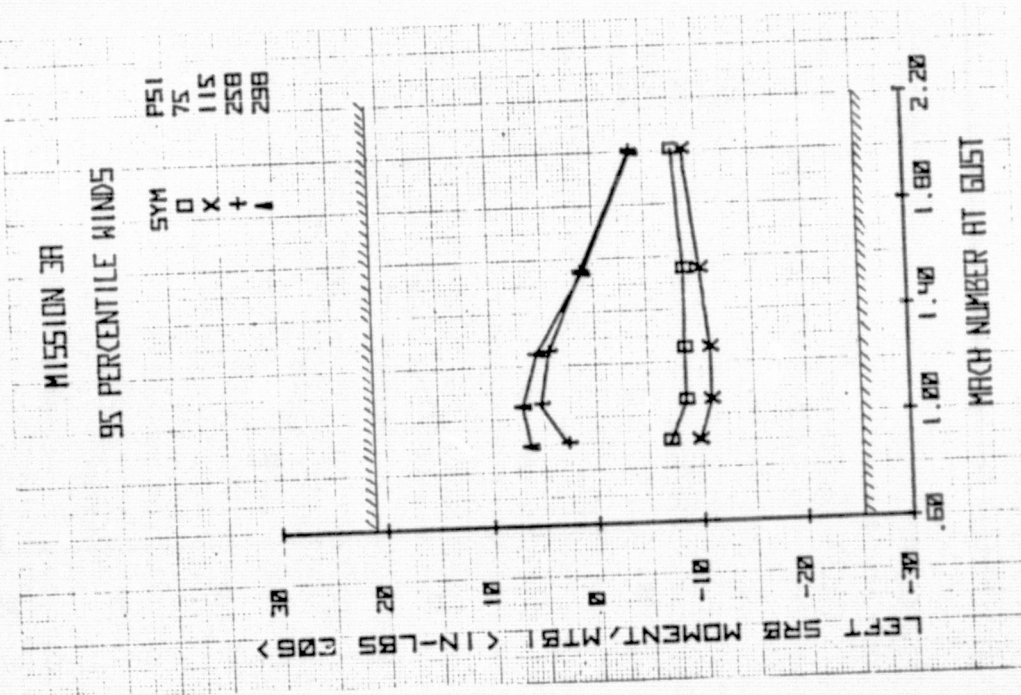
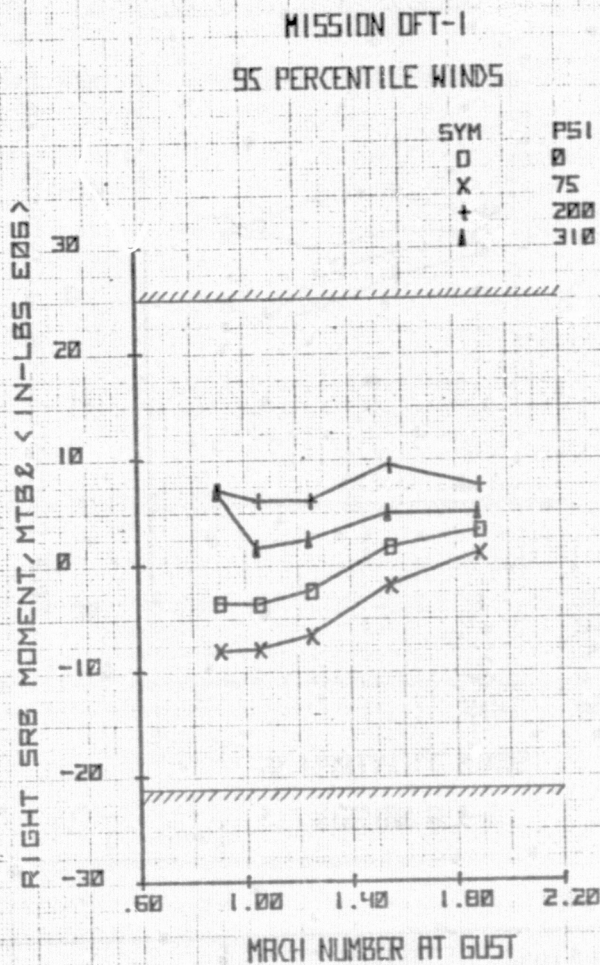
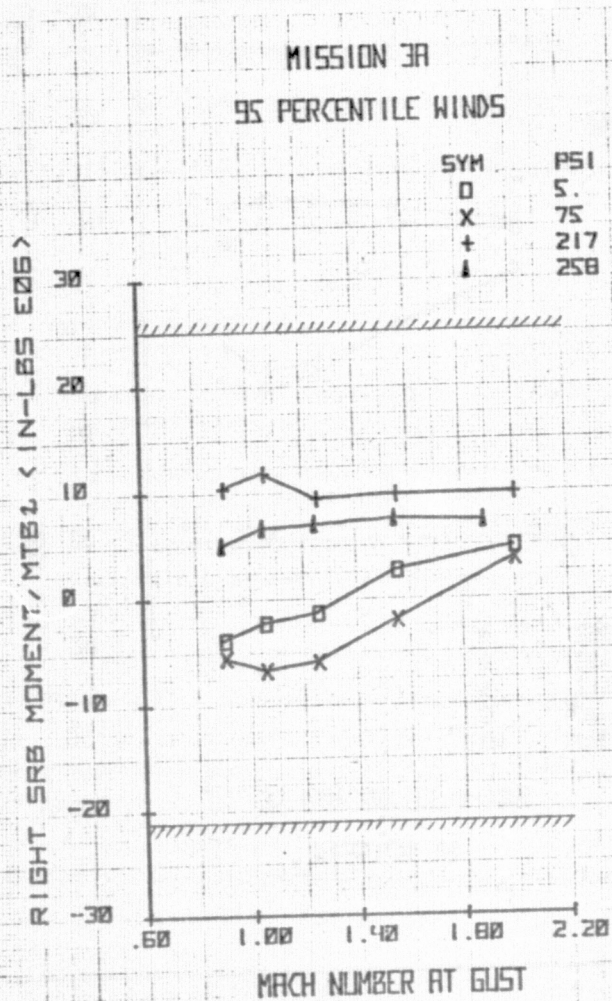


FIGURE 104.- IMPACT OF WINDS ON RIGHT SRB MOMENT/MTB2

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

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FIGURE 105.- IMPACT OF 95 PERCENTILE WINDS/WING ROOT BENDING

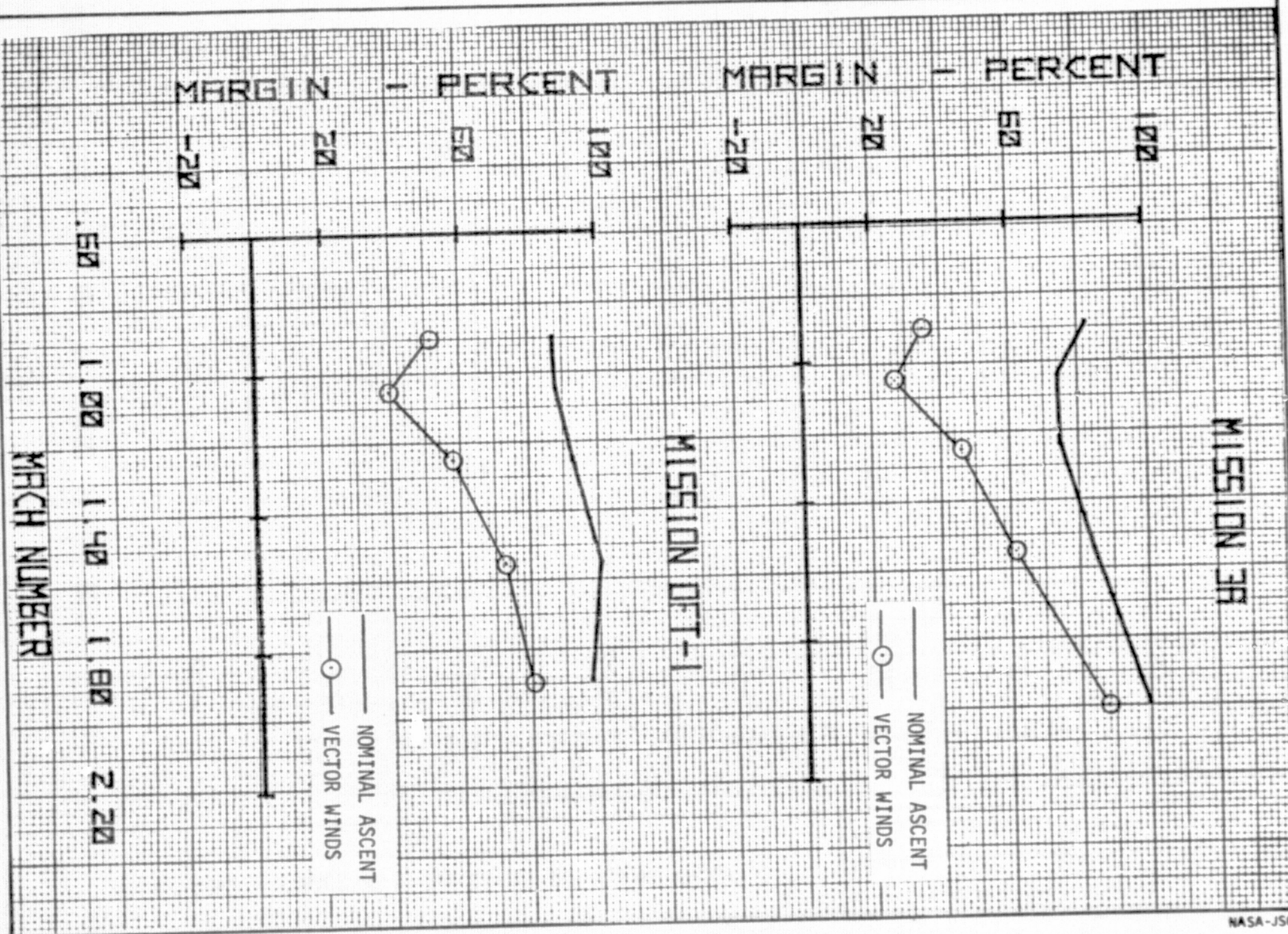
ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

BY L. Austin

PLOT NO.



NASA-JSC

FIGURE 106.- IMPACT OF 95 PERCENTILE WINDS/WING SHEAR

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

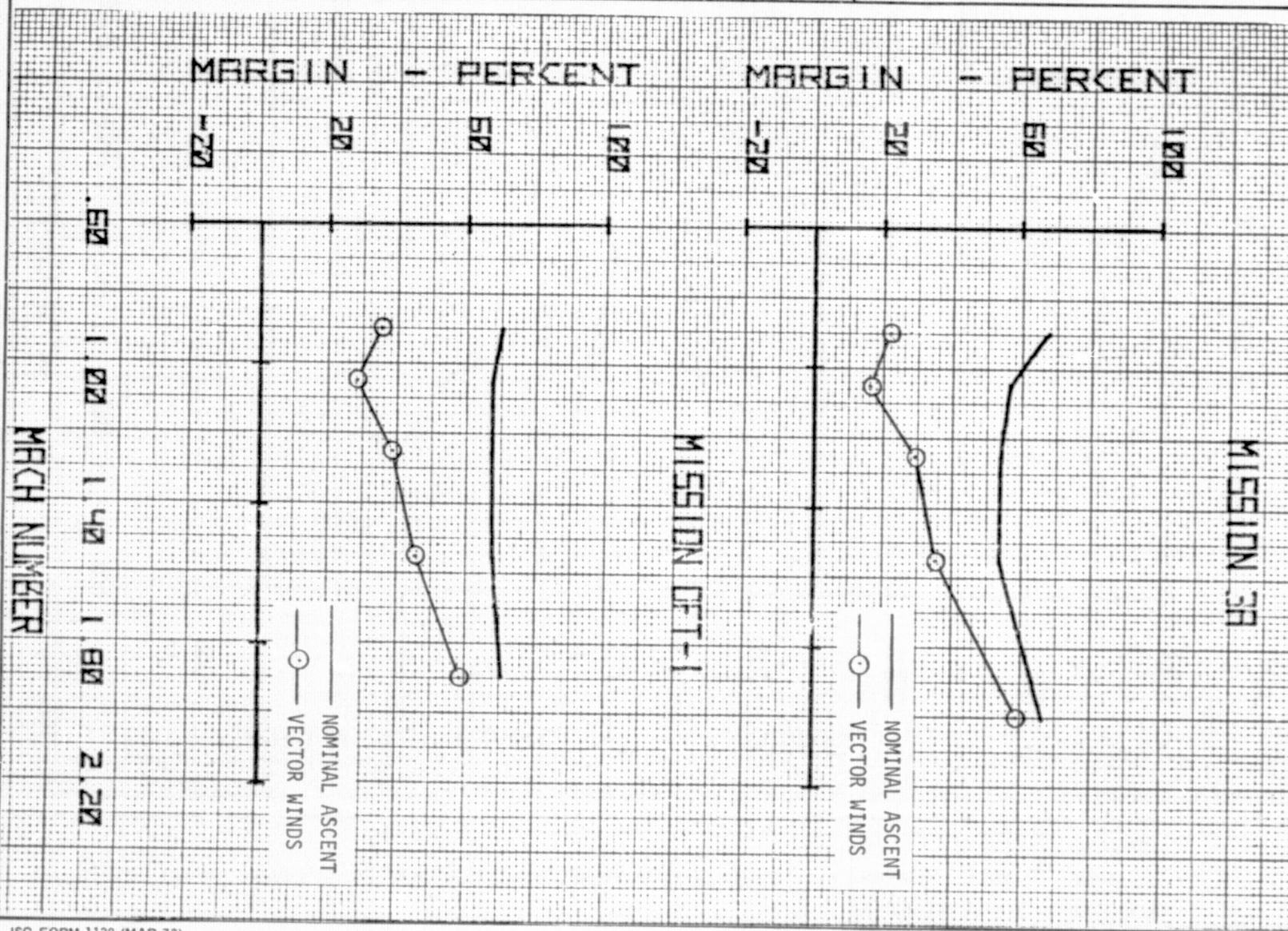


FIGURE 107.- IMPACT OF 95 PERCENTILE WINDS/OUTBOARD
ELEVON HINGE MOMENT

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

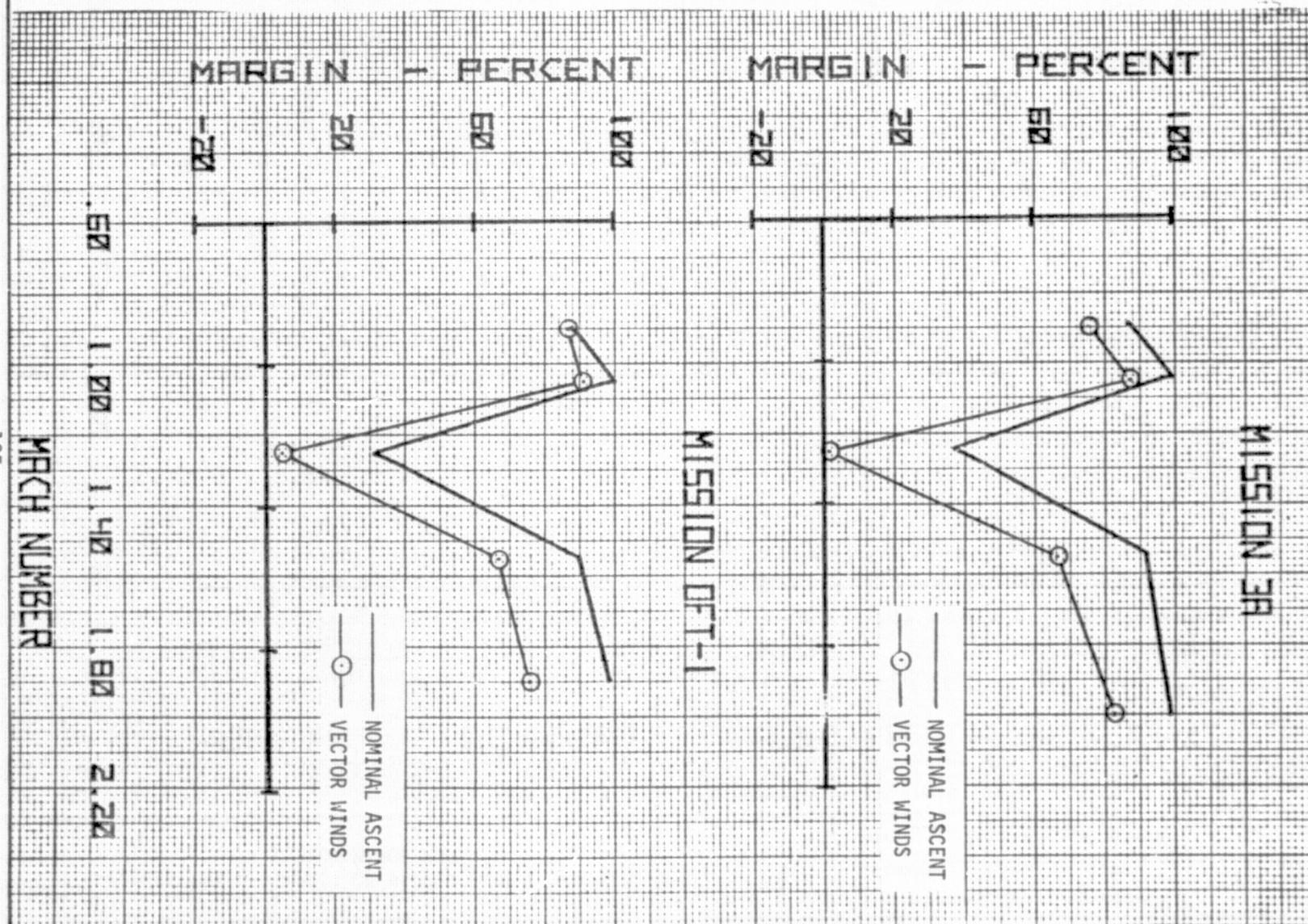
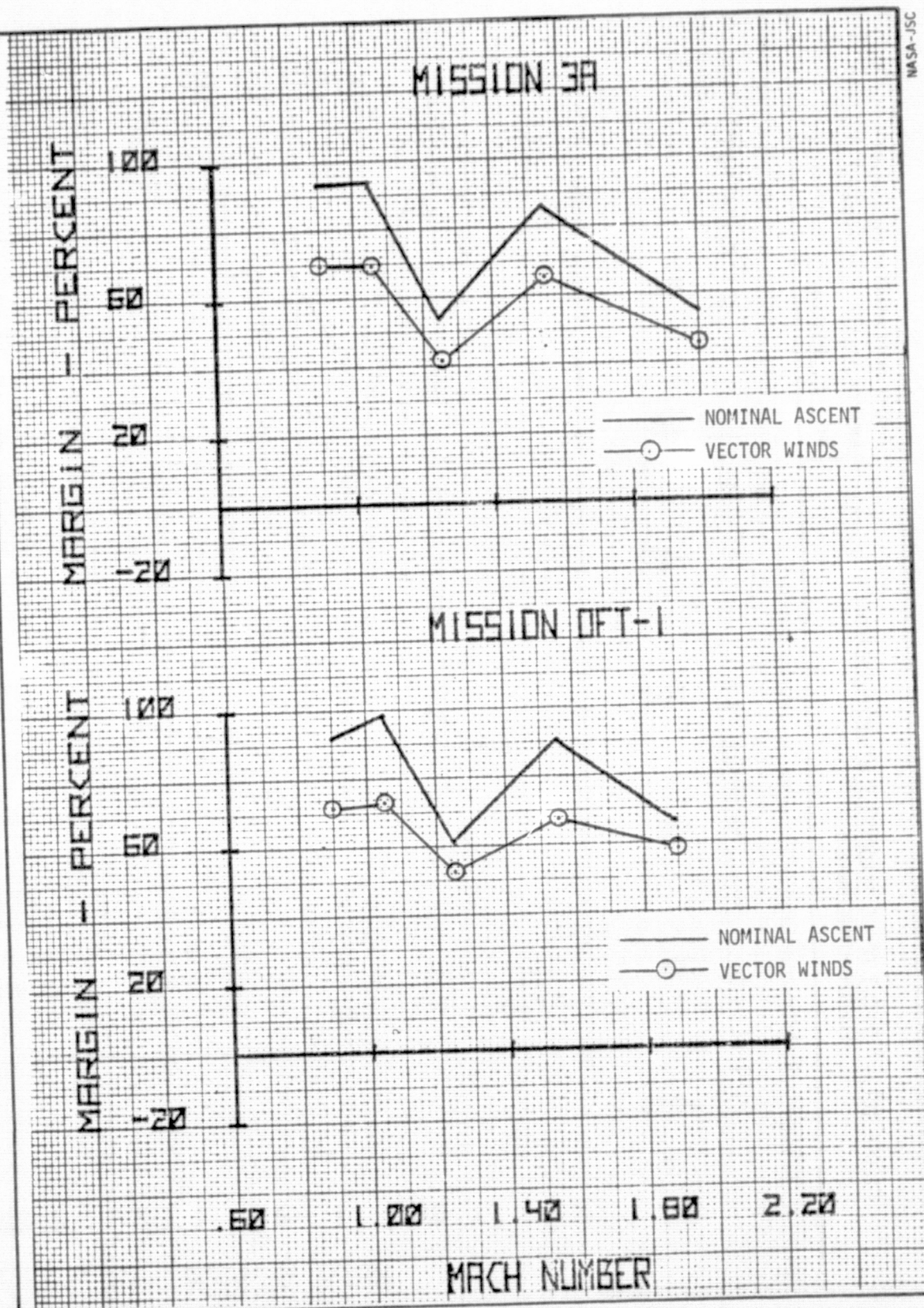


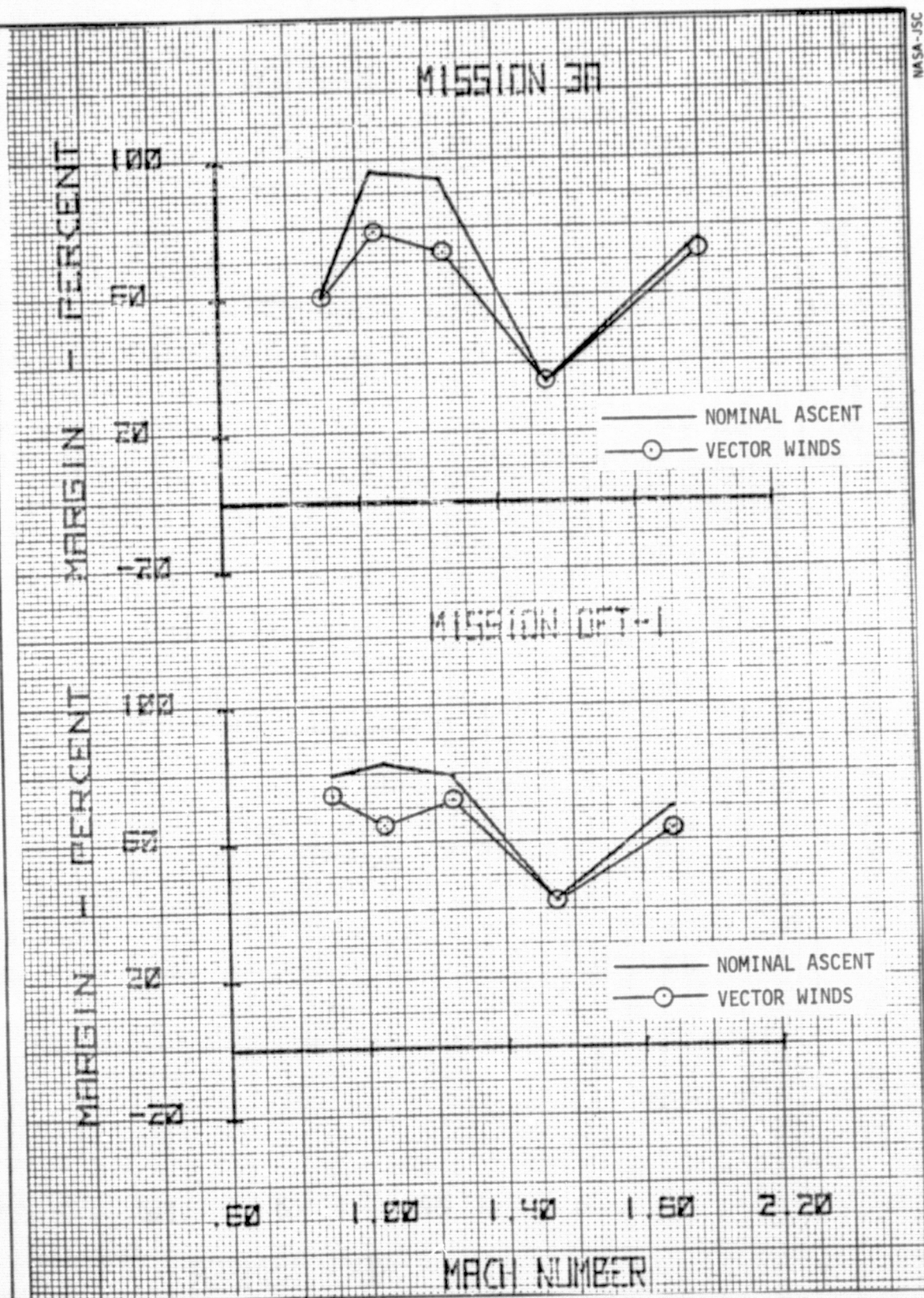
FIGURE 108.- IMPACT OF 95 PERCENTILE WINDS/INBOARD
ELEVON HINGE MOMENT

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

FIGURE 109.- IMPACT OF 95 PERCENTILE WINDS/FT01



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JSC FORM 1138 (MAR 73)

FIGURE 110.- IMPACT OF 95 PERCENTILE WINDS/FT02

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

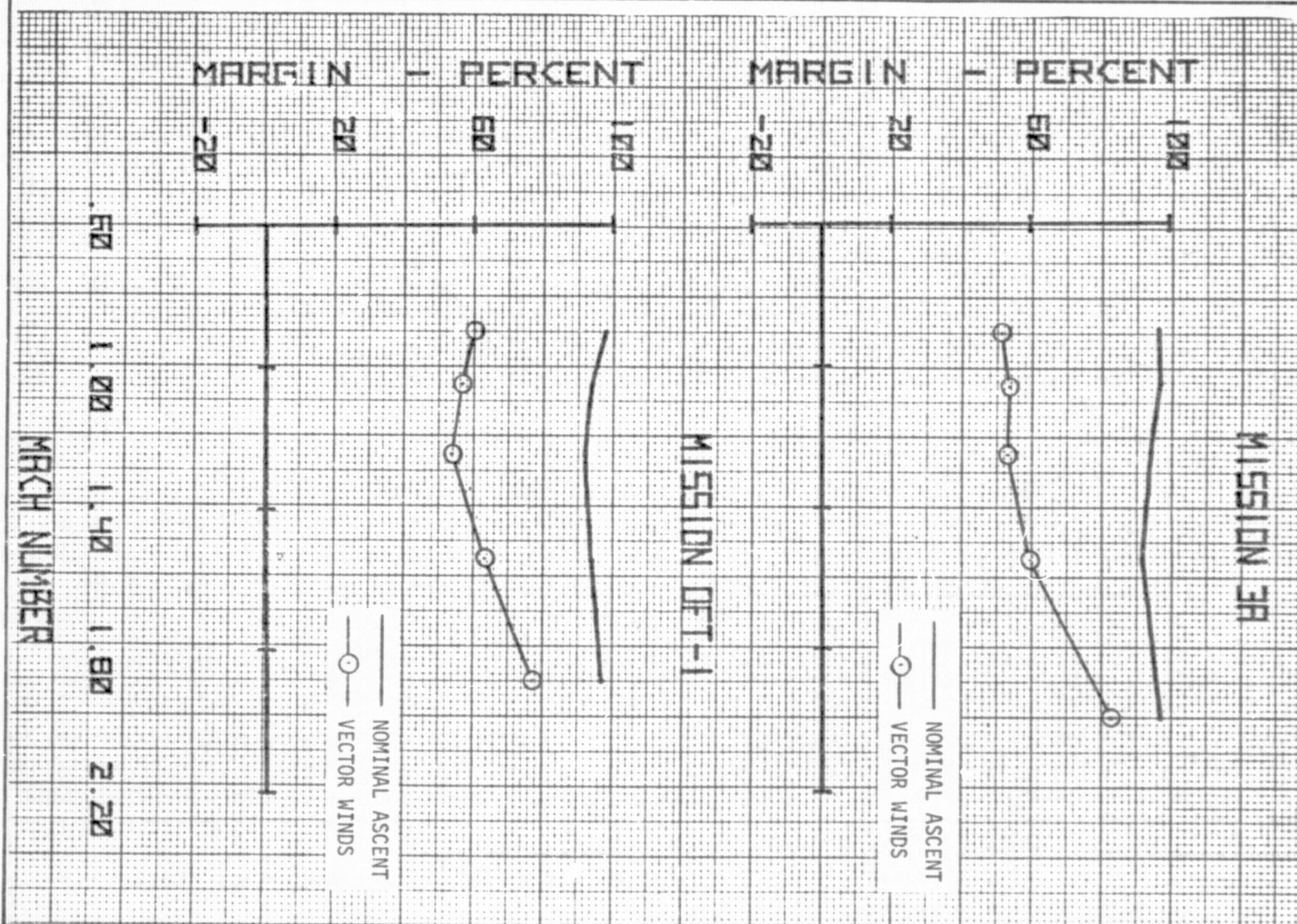


FIGURE 111.- IMPACT OF 95 PERCENTILE WINDS/FT03

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

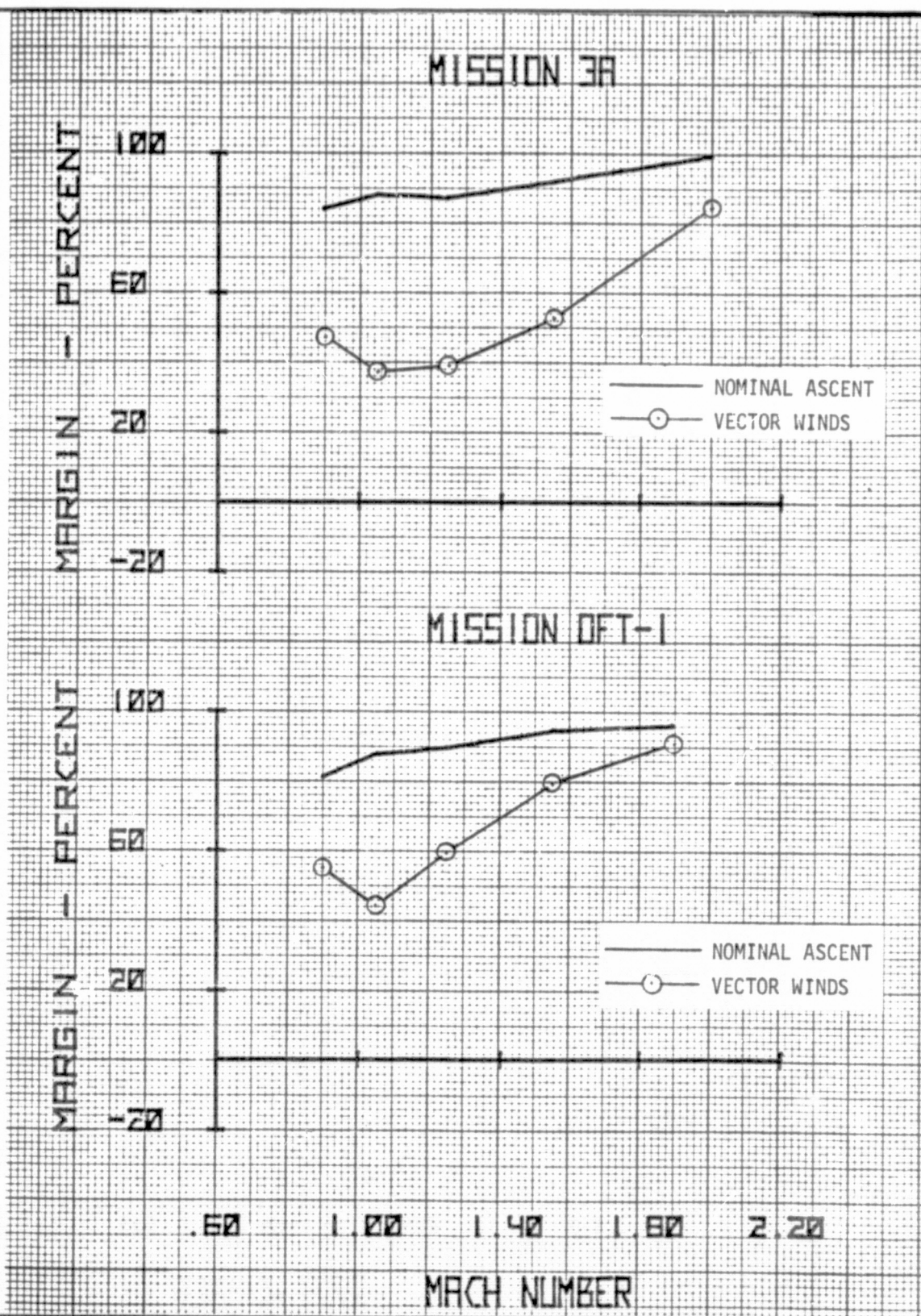
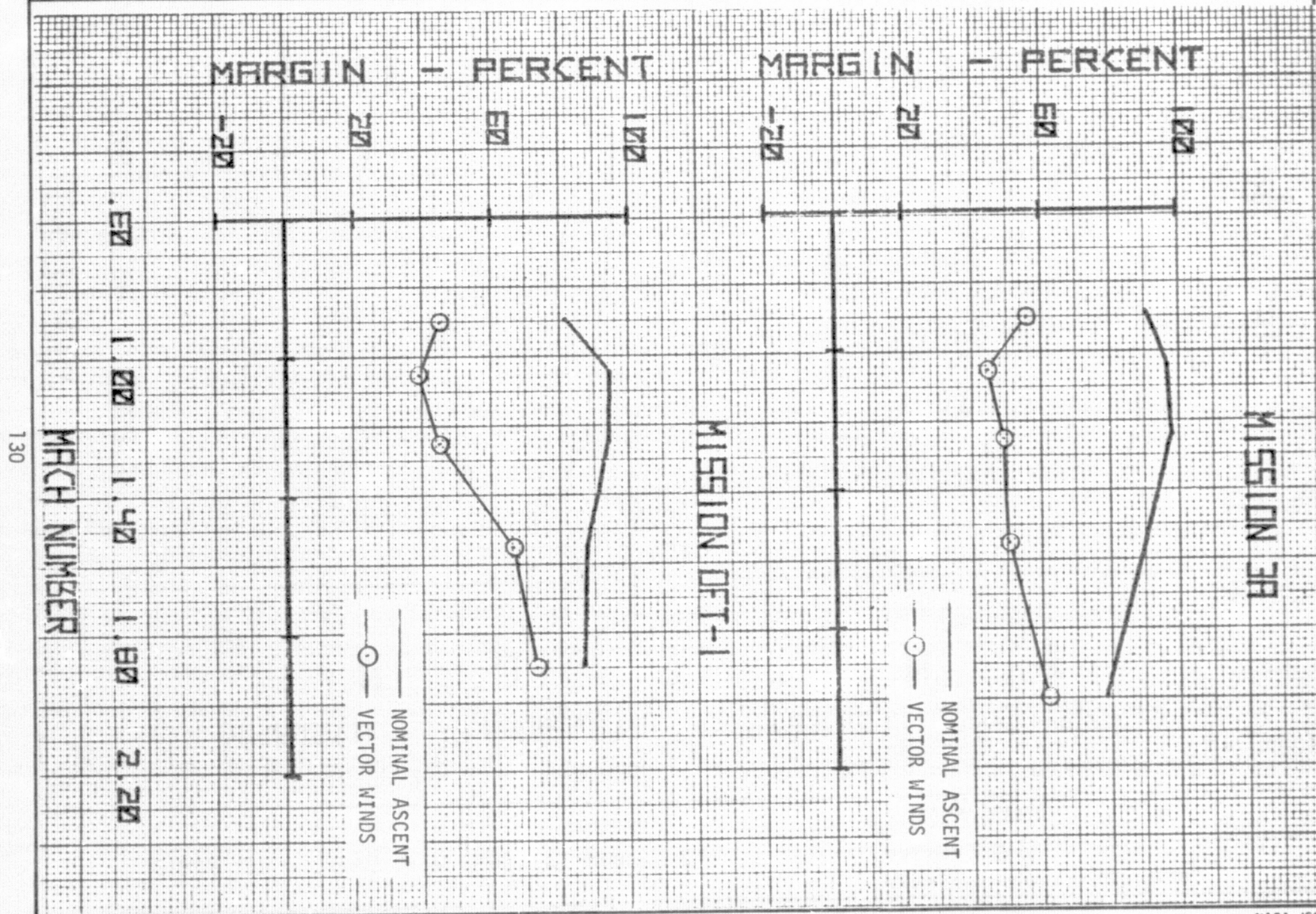


FIGURE 112.- IMPACT OF 95 PERCENTILE WINDS/FT04

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

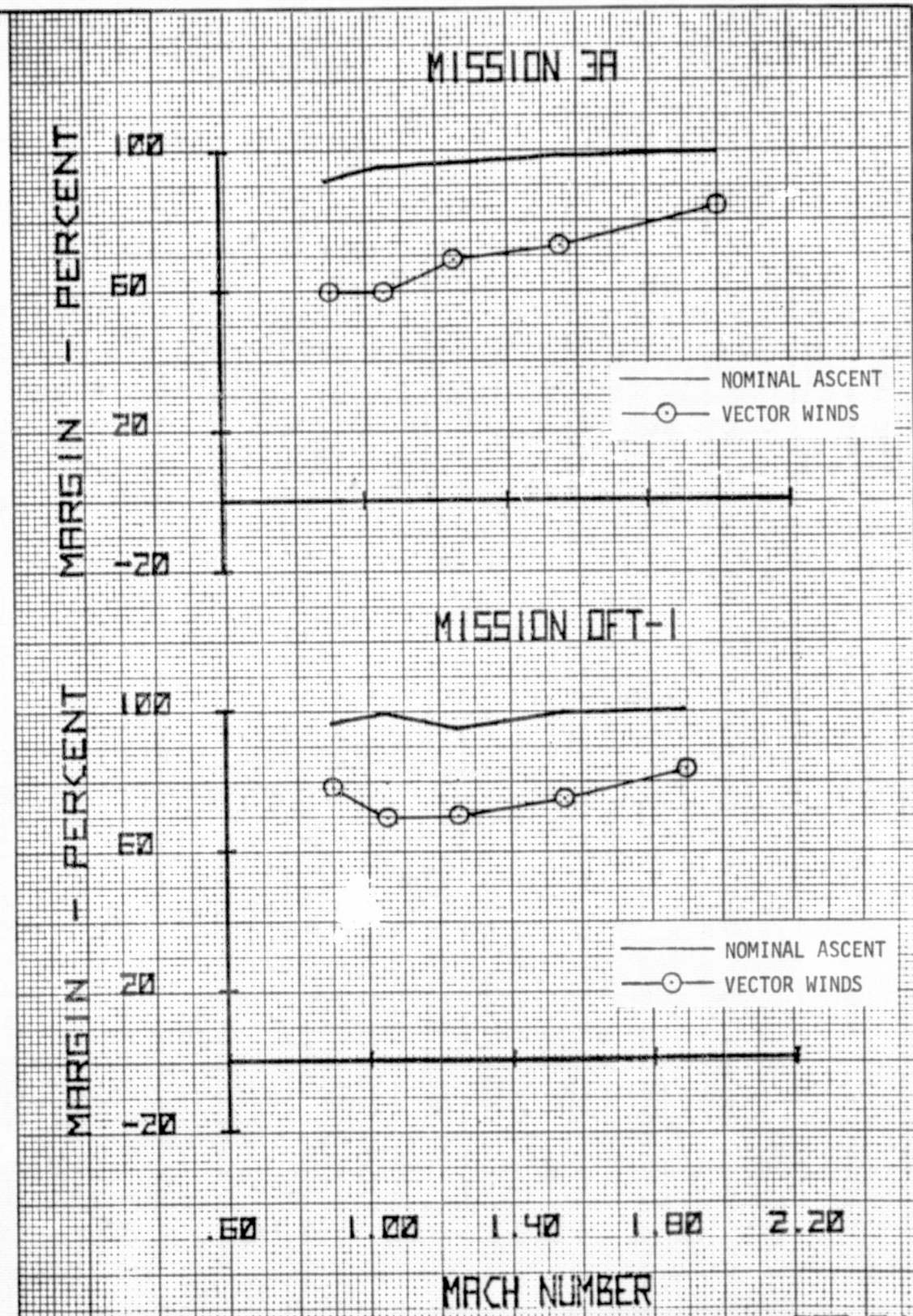


ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

FIGURE 113.- IMPACT OF 95 PERCENTILE WINDS/FT06

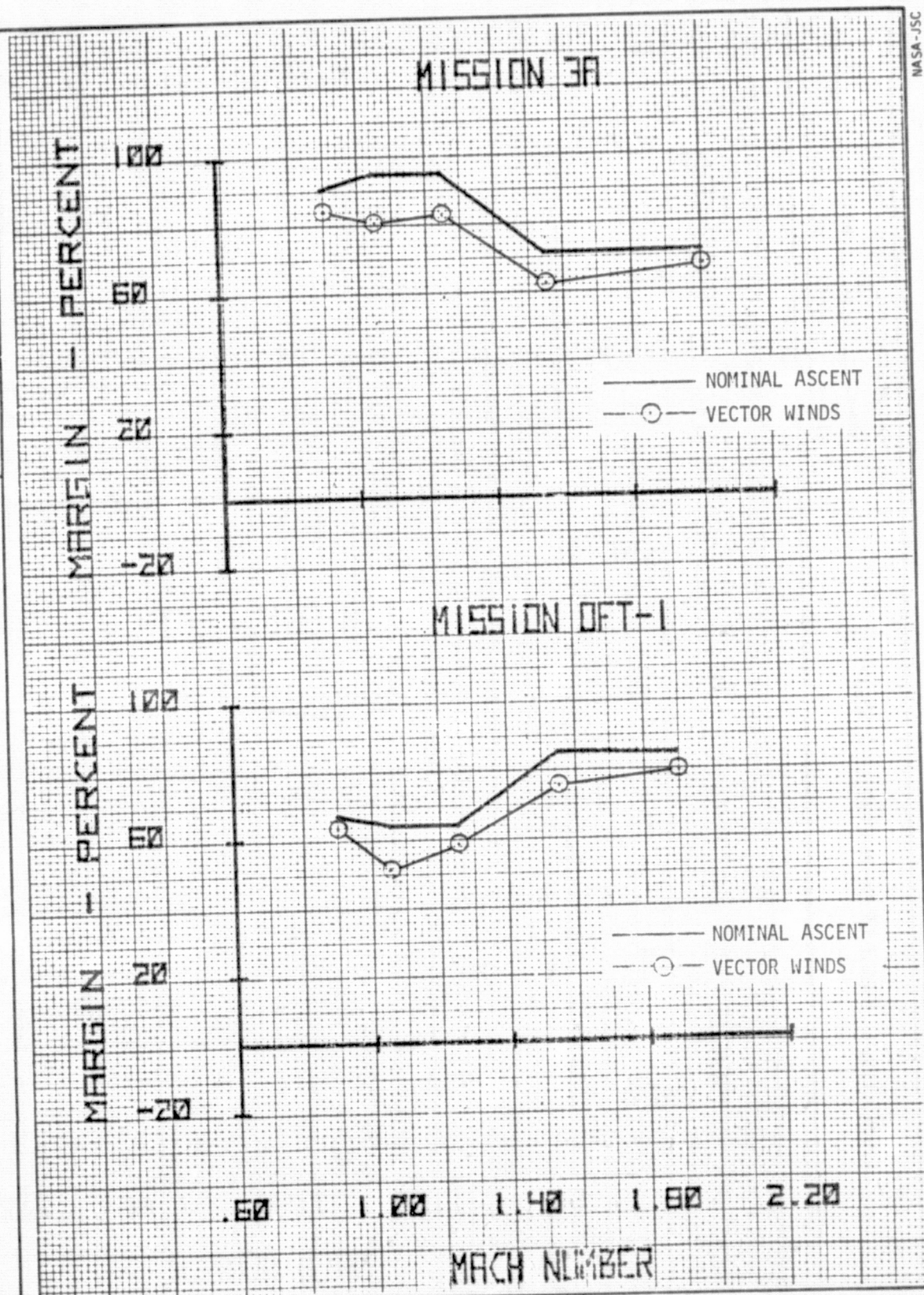


ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

FIGURE 114.- IMPACT OF 95 PERCENTILE WINDS/FT07



NASA-JSC

JSC FORM 1136 (MAR 73)

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

FIGURE 115.- IMPACT OF 95 PERCENT WINDS/FT08

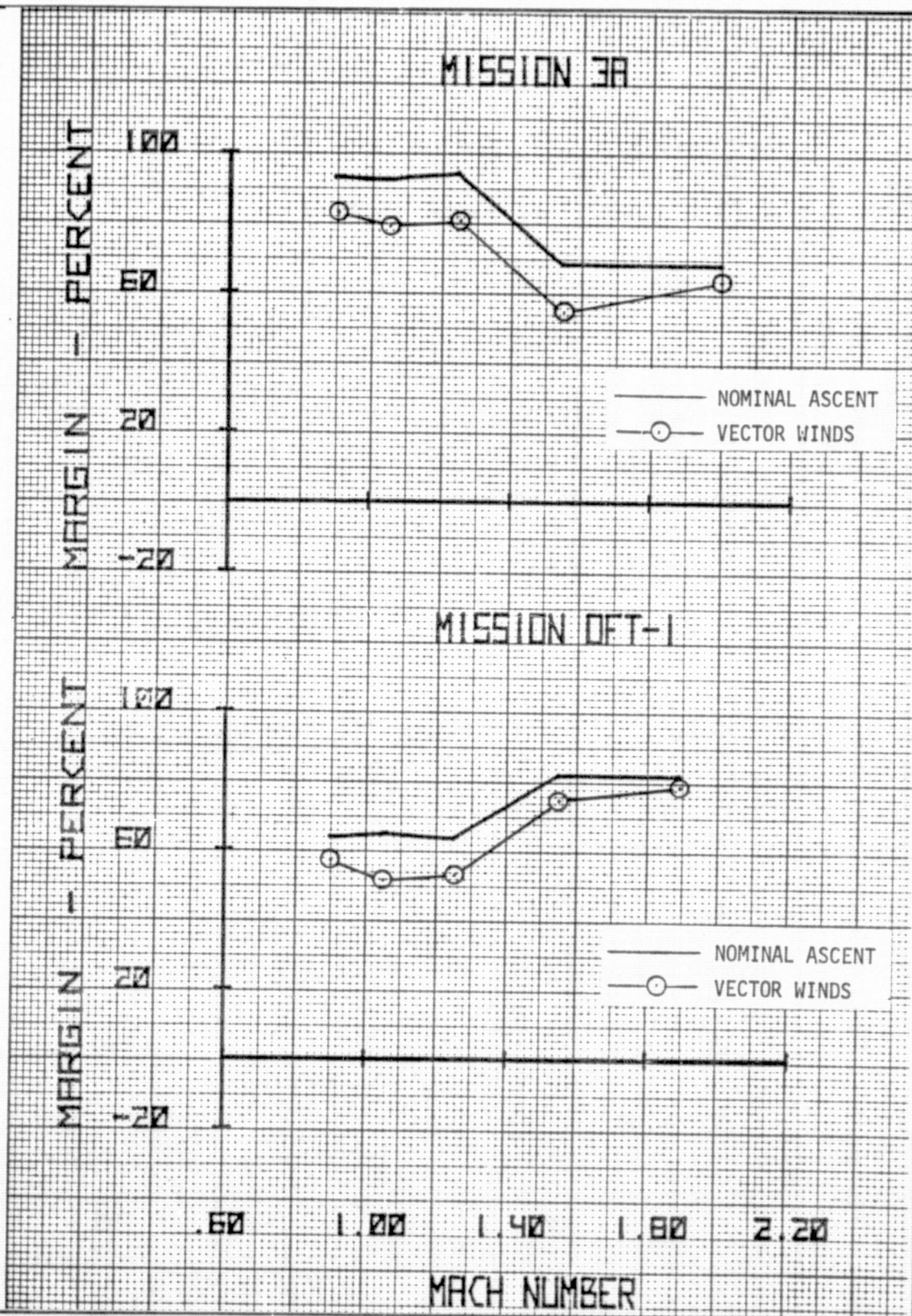


FIGURE 116.- IMPACT OF 95 PERCENTILE WINDS/FTB 1,2

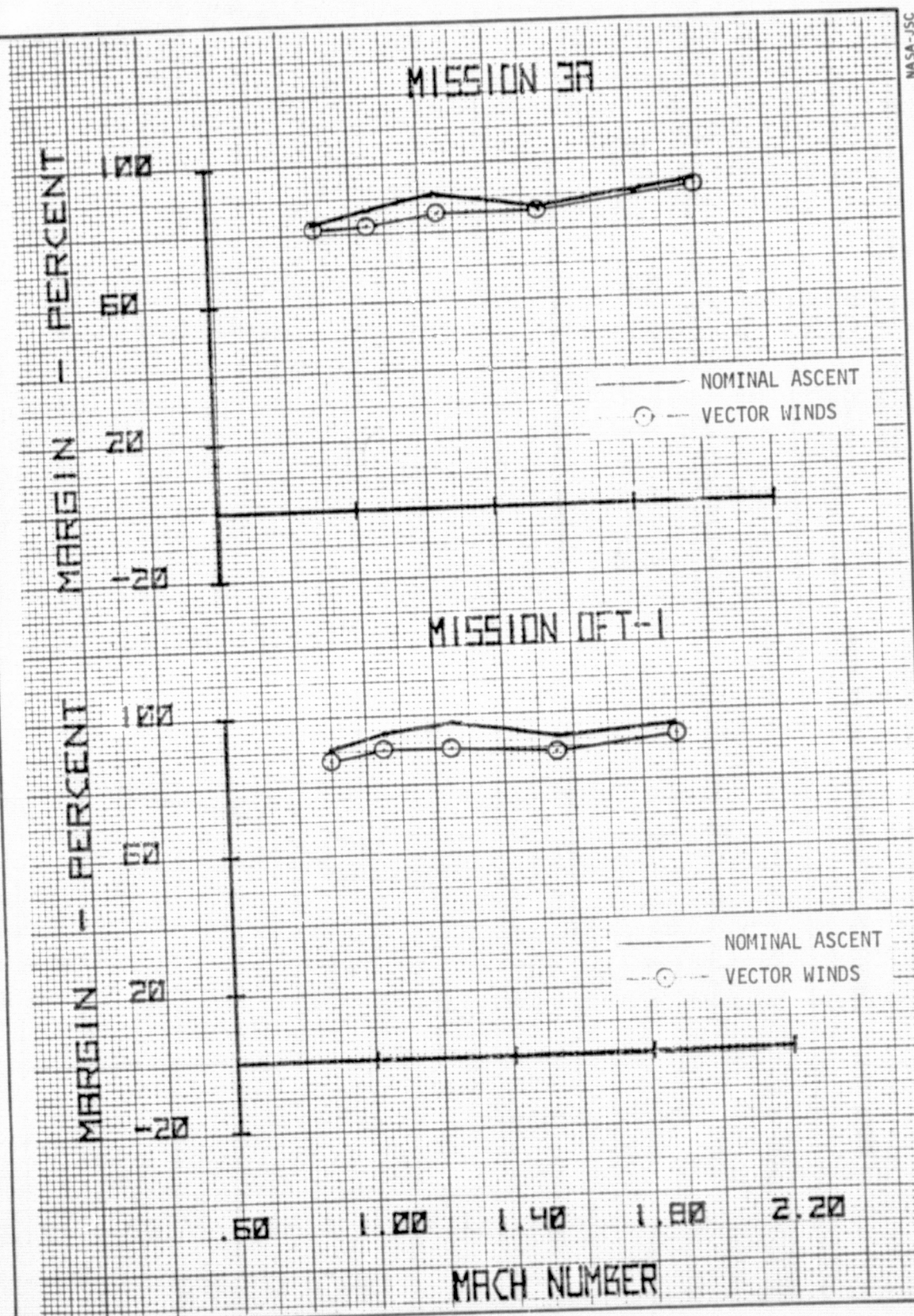
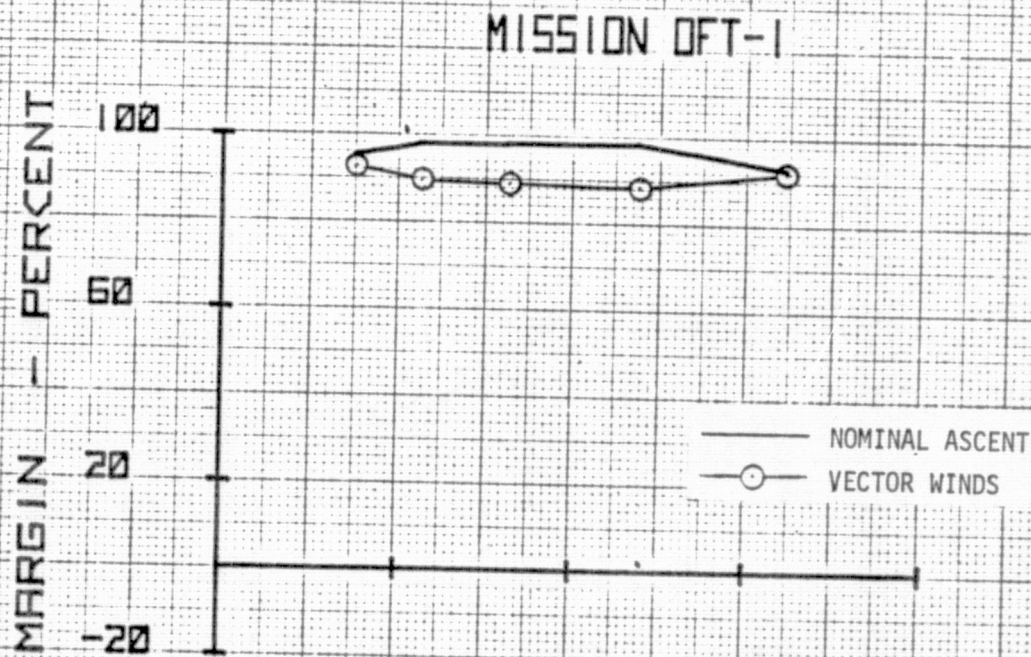
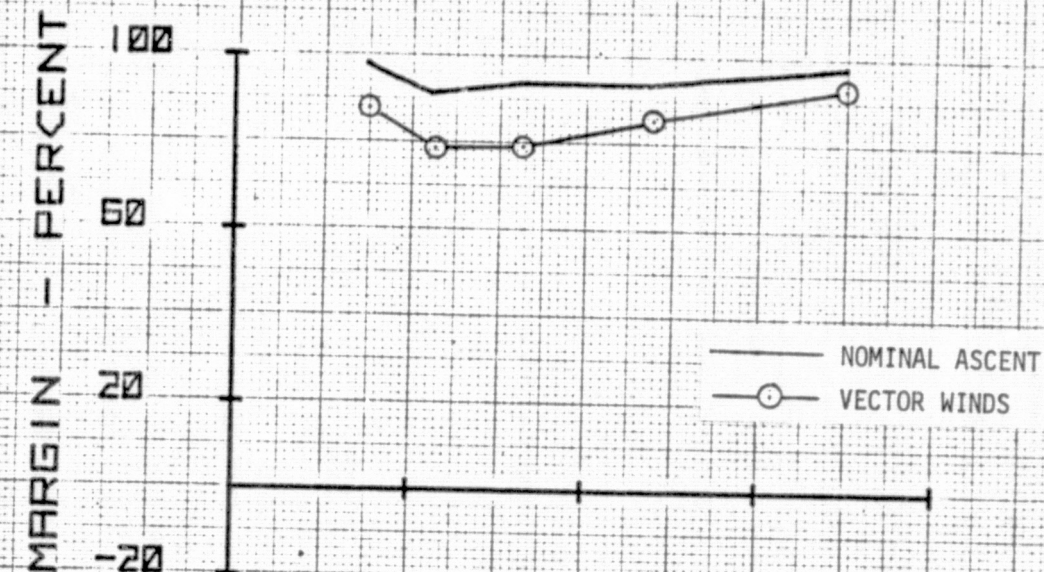


FIGURE 117.- IMPACT OF 95 PERCENTILE WINDS/FTB 3,4

ENGINEERING ANALYSIS DIVISION/EX

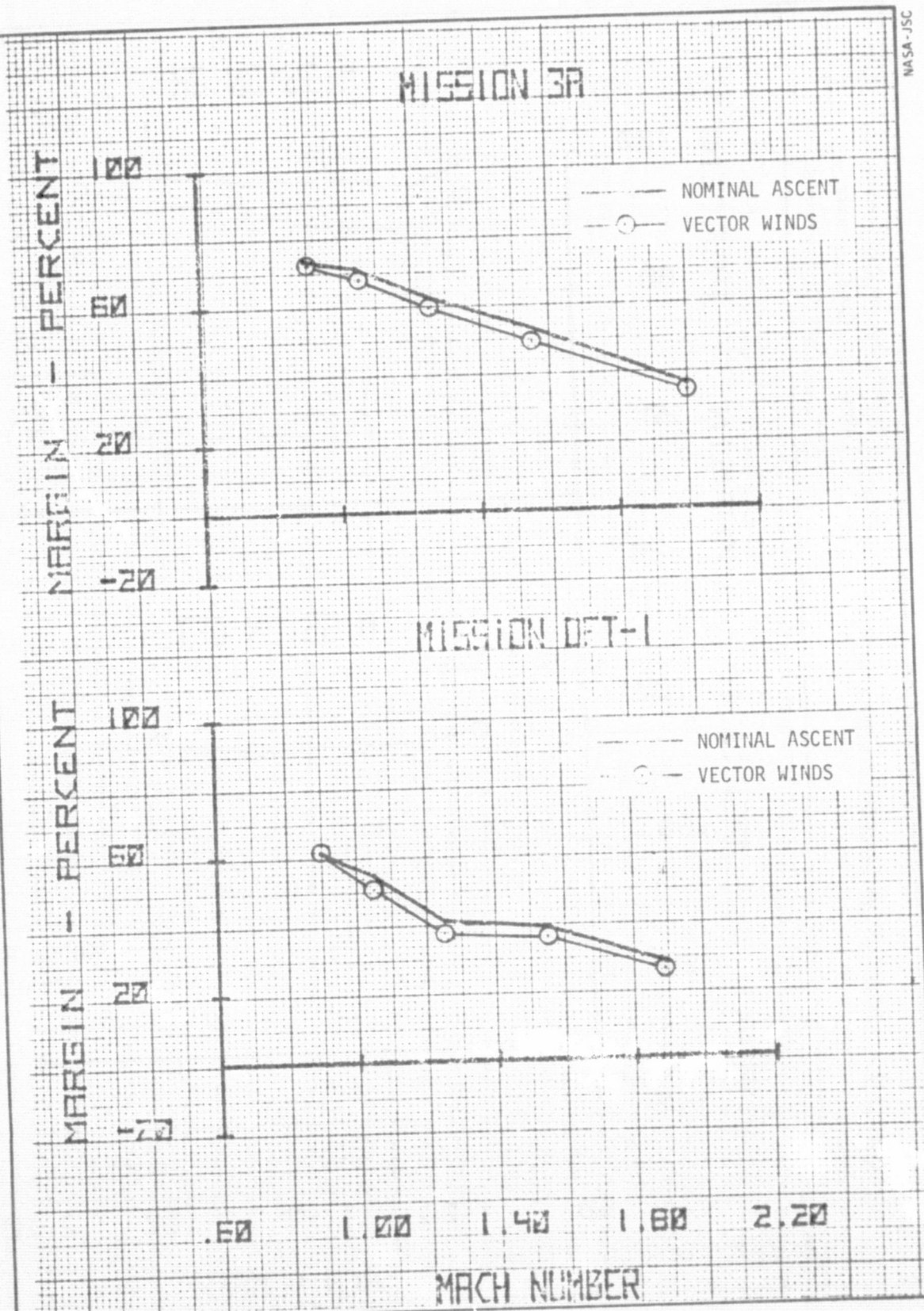
BRANCH EX42 DATE

BY L. Austin PLOT NO.



MACH NUMBER

FIGURE 118.- IMPACT OF 95 PERCENTILE WINDS/FTO 5,6



ENGINEERING ANALYSIS DIVISION/EX
 BRANCH EX42 DATE
 BY L. Austin PLOT NO.

FIGURE 119.- IMPACT OF 95 PERCENTILE WINDS/FTB 7,8

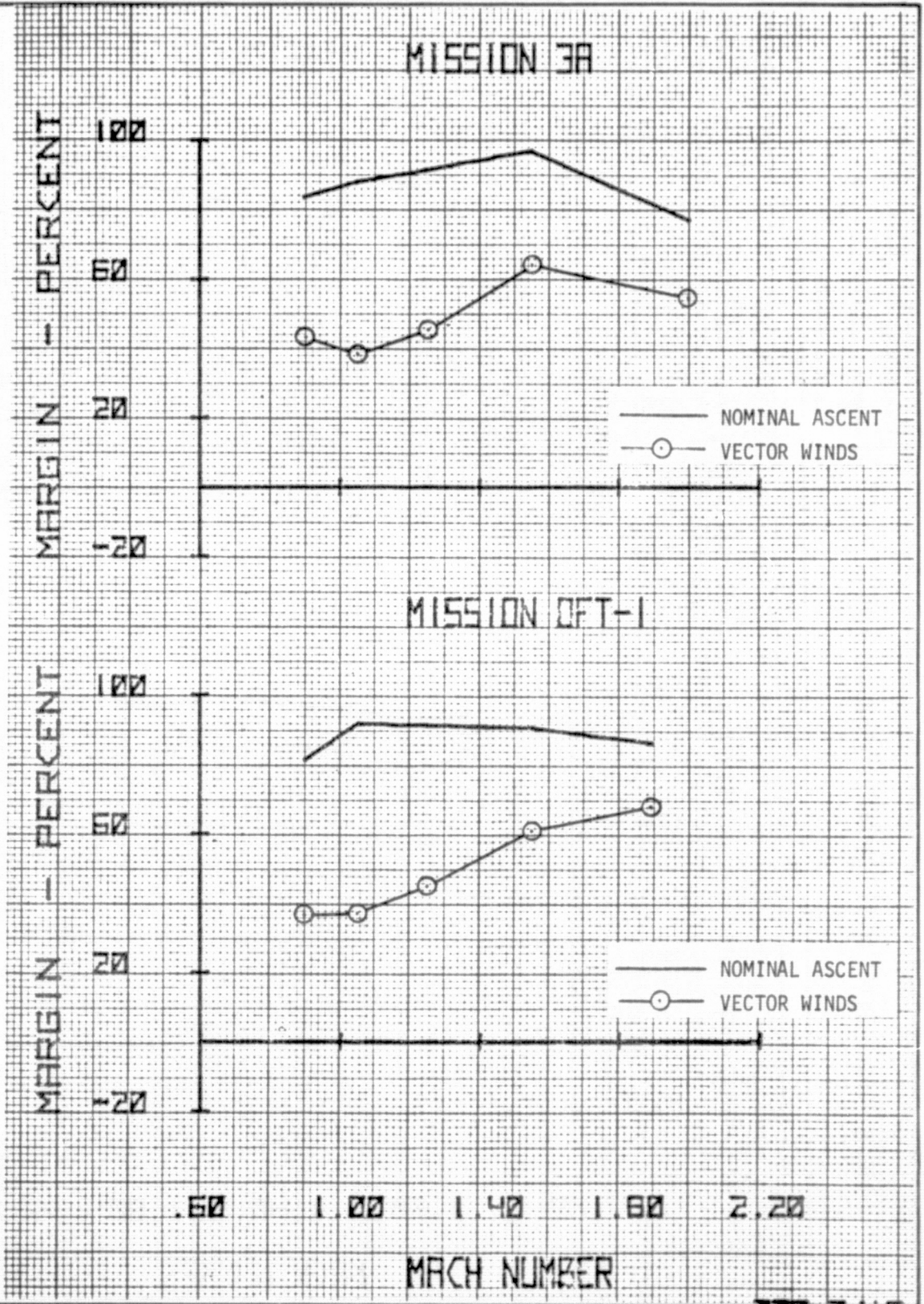


FIGURE 120.- IMPACT OF 95 PERCENTILE WINDS/FTB 9,10

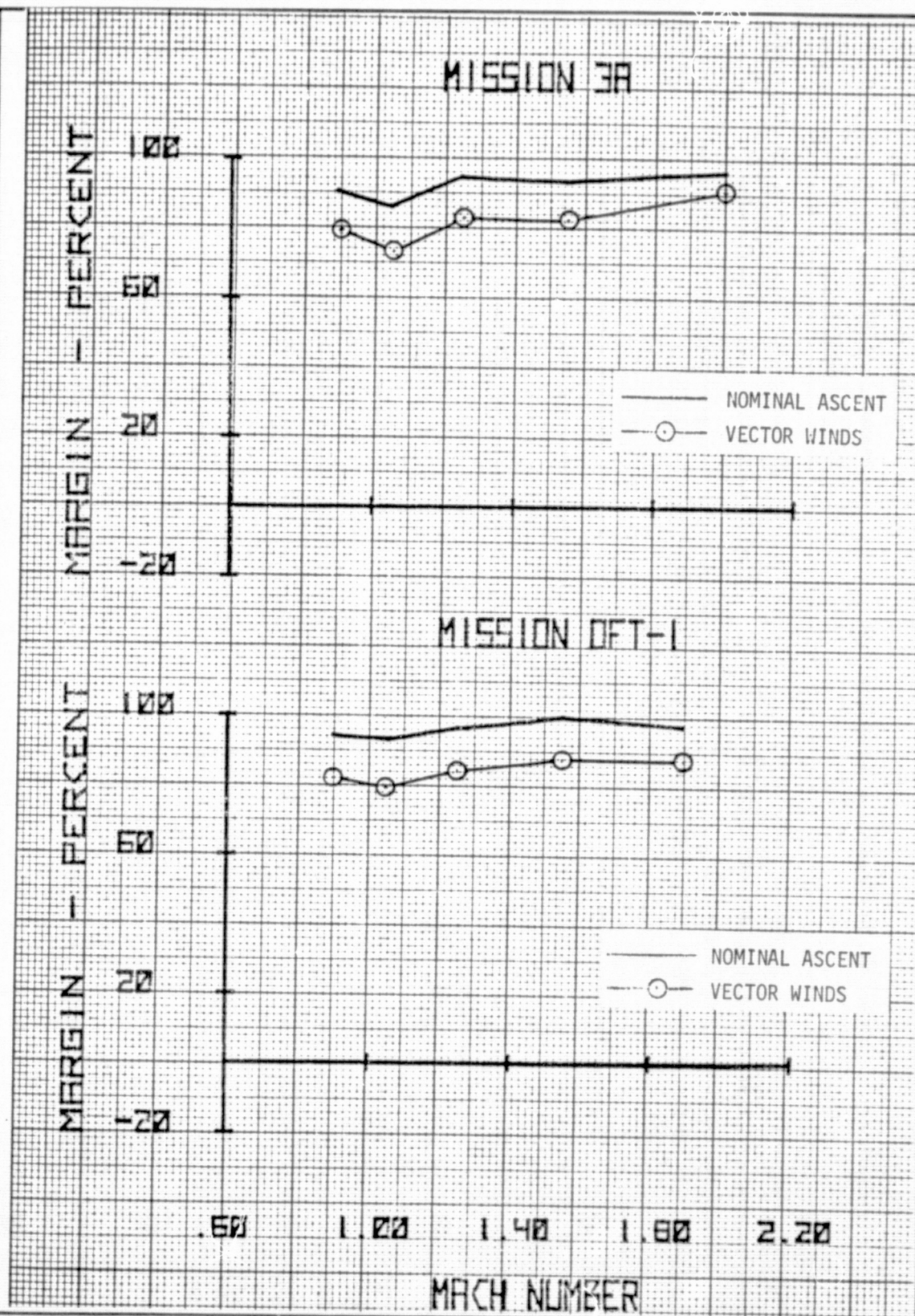


FIGURE 121.- IMPACT OF 95 PERCENTILE WINDS/MTB 1,2

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE _____

BY L. Austin PLOT NO. _____

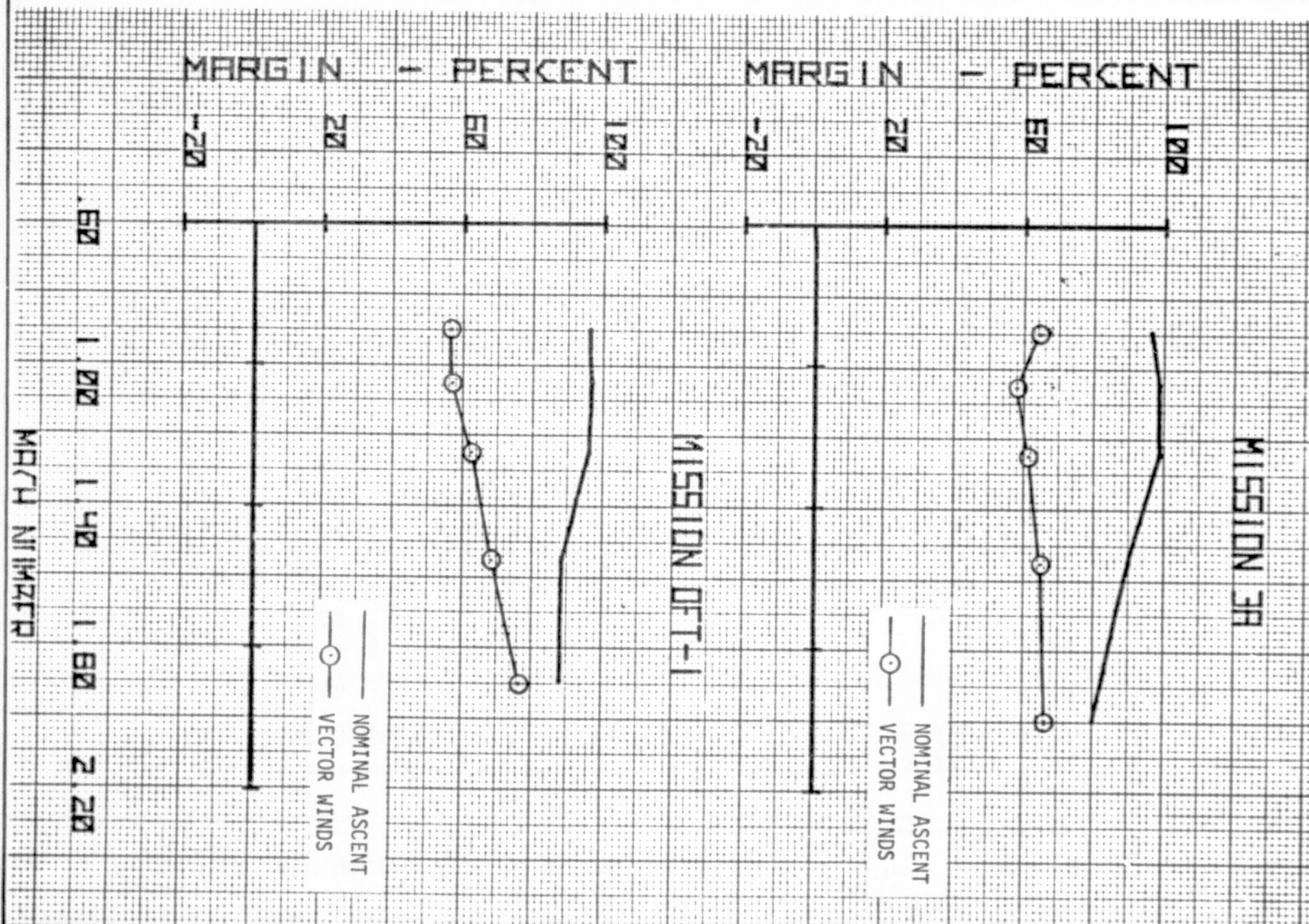


FIGURE 122.- MINIMUM LOAD INDICATOR MARGINS (%) / MISSION 3A

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

LOAD INDICATOR	NOMINAL 3A	DECEMBER VECTOR WINDS
WRB	74	27
WS	54	16
HMO	37	3
HMI	54	42
FT01	35	34
FT02	92	51
FT03	84	37
FT04	78	44
FT06	91	60
FT07	71	62
FT08	68	55
FTB1, 2	83	82
FTB3, 4	91	79
FTB5, 6	36	34
FTB7, 8	77	38
FTB9, 10	86	73
MTB1, 2	81	58

NOTE: $0.9 \leq \text{MACH} \leq 2.0$

FIGURE 123.- MINIMUM LOAD INDICATOR MARGIN (%) /OFT-1

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

LOAD INDICATOR	NOMINAL OFT-1	APRIL VECTOR WINDS
WRB	87	40
WS	67	28
HMO	31	5
HMI	61	52
FT01	43	43
FT02	92	54
FT03	81	44
FT04	81	40
FT06	94	70
FT07	64	52
FT08	64	52
FTB1, 2	90	87
FTB3, 4	93	91
FTB5, 6	28	26
FTB7, 8	81	37
FTB9, 10	93	80
MTB1, 2	88	57

NOTE: $0.9 \leq \text{MACH} \leq 2.0$

FIGURE 124.- MAXIMUM DYNAMIC PRESSURE SENSITIVITY TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION / EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

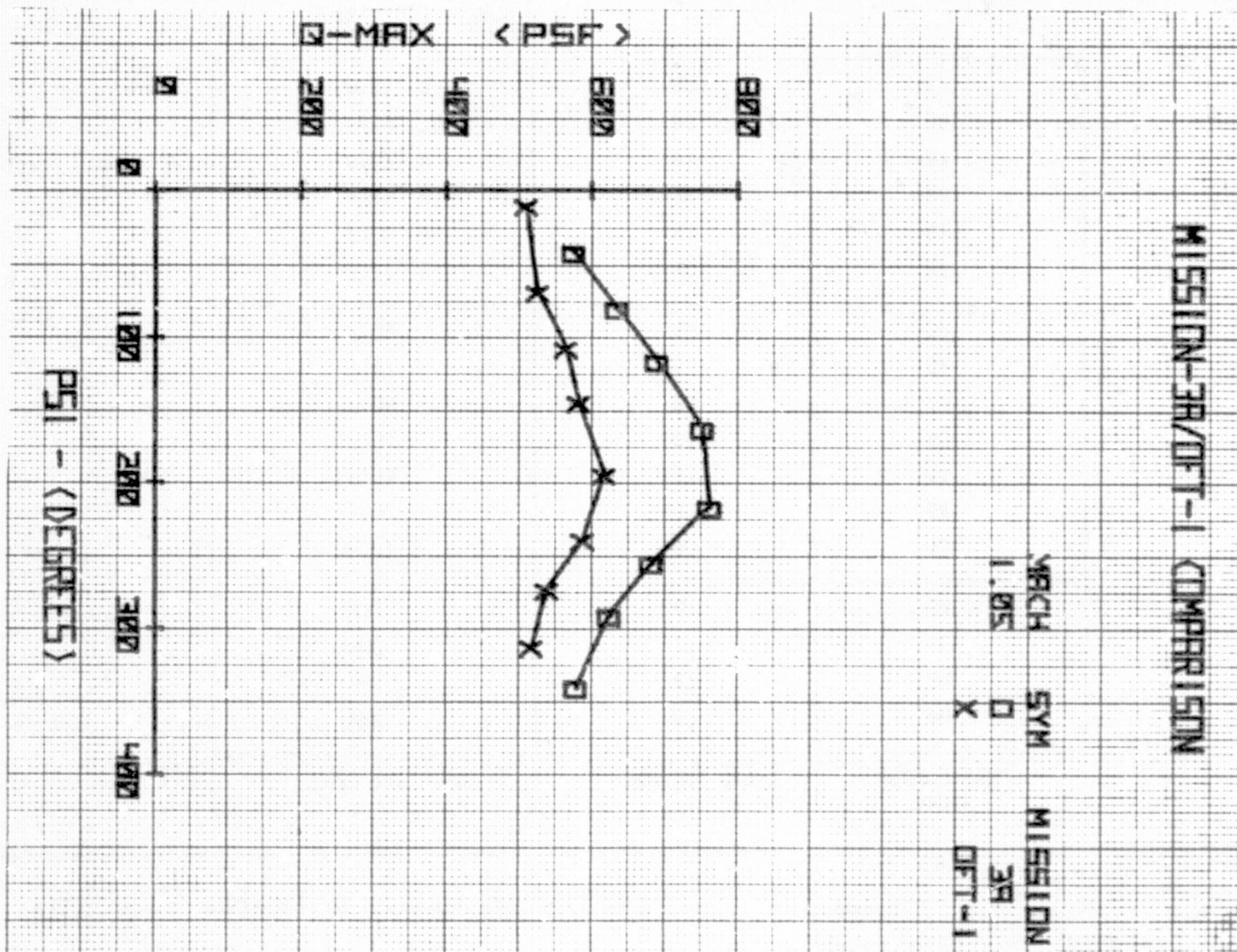


FIGURE 125.- IMPACT OF WINDS ON SSV MAXIMUM DYNAMIC PRESSURE

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE _____

BY L. Austin PLOT NO. _____

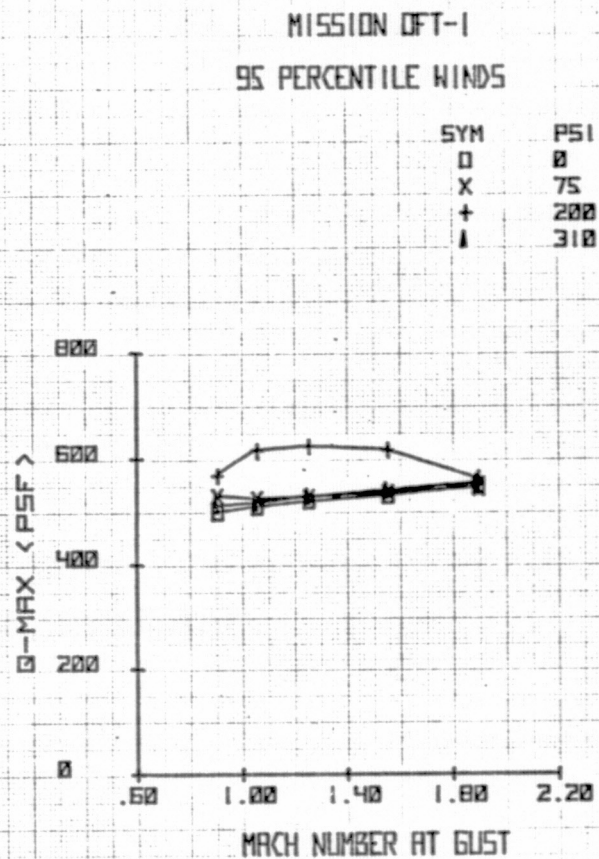
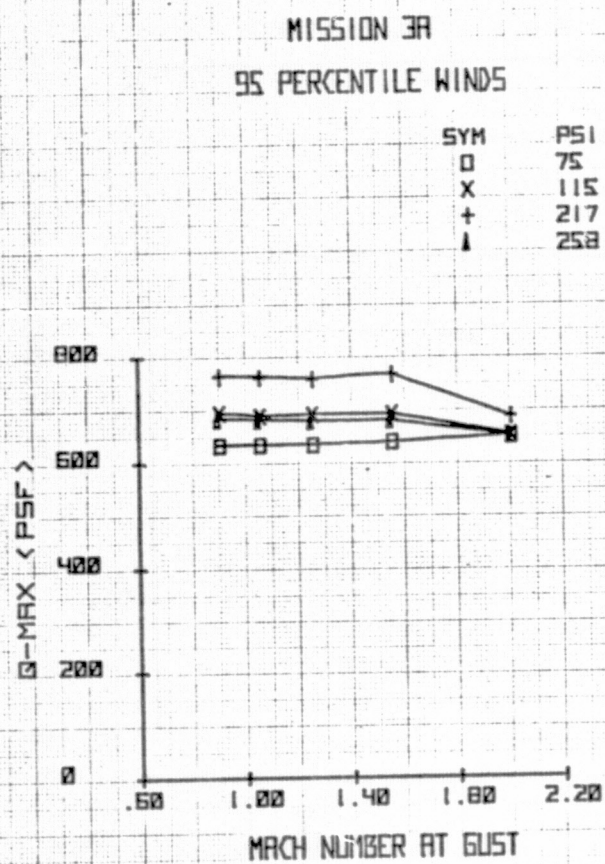


FIGURE 126.- FLUTTER MARGIN/WORST CASE VECTOR WINDS

ENGINEERING ANALYSIS DIVISION EX

BRANCH EX42

DATE _____

BY L. Austin

PLOT NO. _____

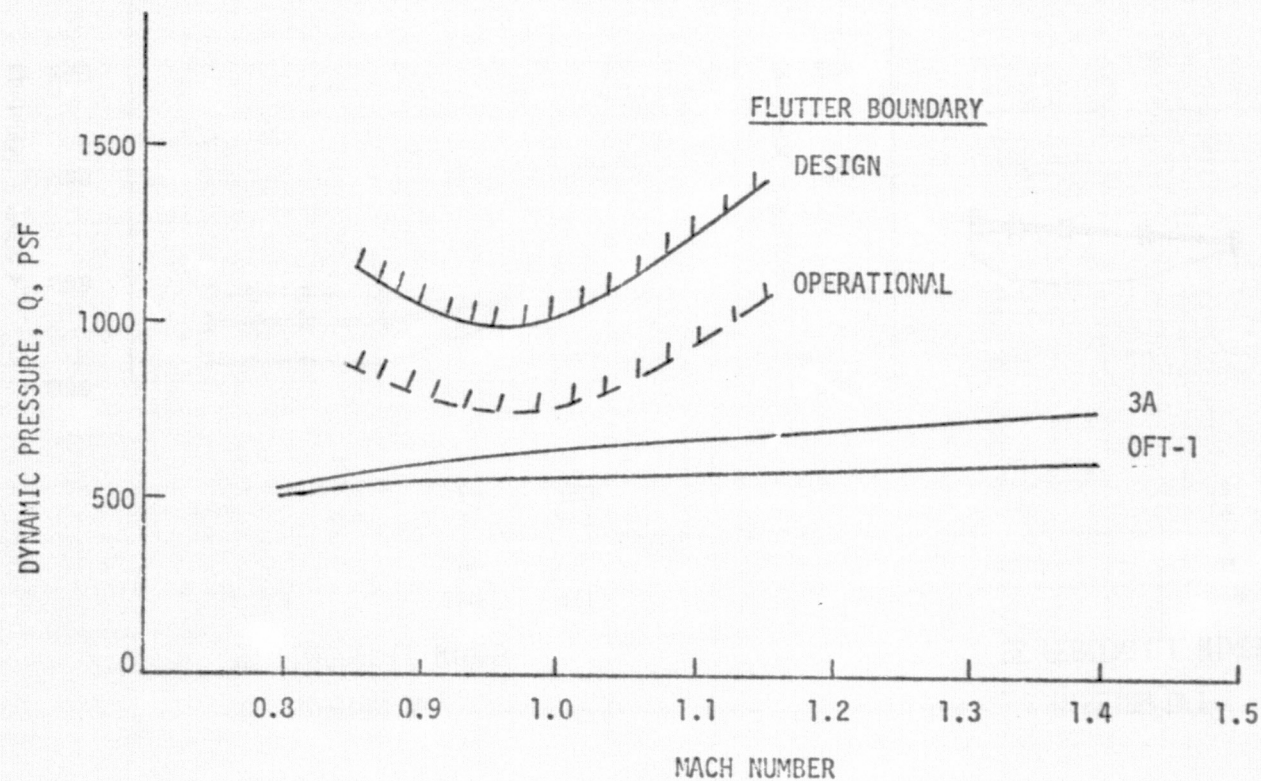


FIGURE 127. - 95 PERCENTILE WIND EFFECTS

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE _____

BY L. Austin

PLOT NO. _____

MISSION	NOMINAL Q _{MAX} , PSF	VECTOR WINDS MAXIMUM Q _{MAX} , PSF	MINIMUM FLUTTER MARGIN, %
3A	650	775	13
OFT-1	550	630	24

FIGURE 128. - 95 PERCENTILE WIND EFFECTS

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

BY L. Austin

PLOT NO.

MISSION	MAXIMUM HEAT RATE, $\dot{q}$, BTU/FT ² /SEC	FIRST STAGE HEAT LOAD, q_s , BTU/FT ²	LOX BULKHEAD LOAD INDICATOR, LBS.
Nominal 3A	3.37	125.01	2,627,000
Wind Effect	± 0.80	± 27	$\pm 55,000$
Nominal OFT-1	1.95	71.3	2,740,000
Wind Effect	± 0.35	± 12	$\pm 55,000$

FIGURE 129.- SSV MAXIMUM FIRST STAGE HEAT RATE SENSITIVITY
TO VARIATIONS IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE

BY L. Austin

PLOT NO.

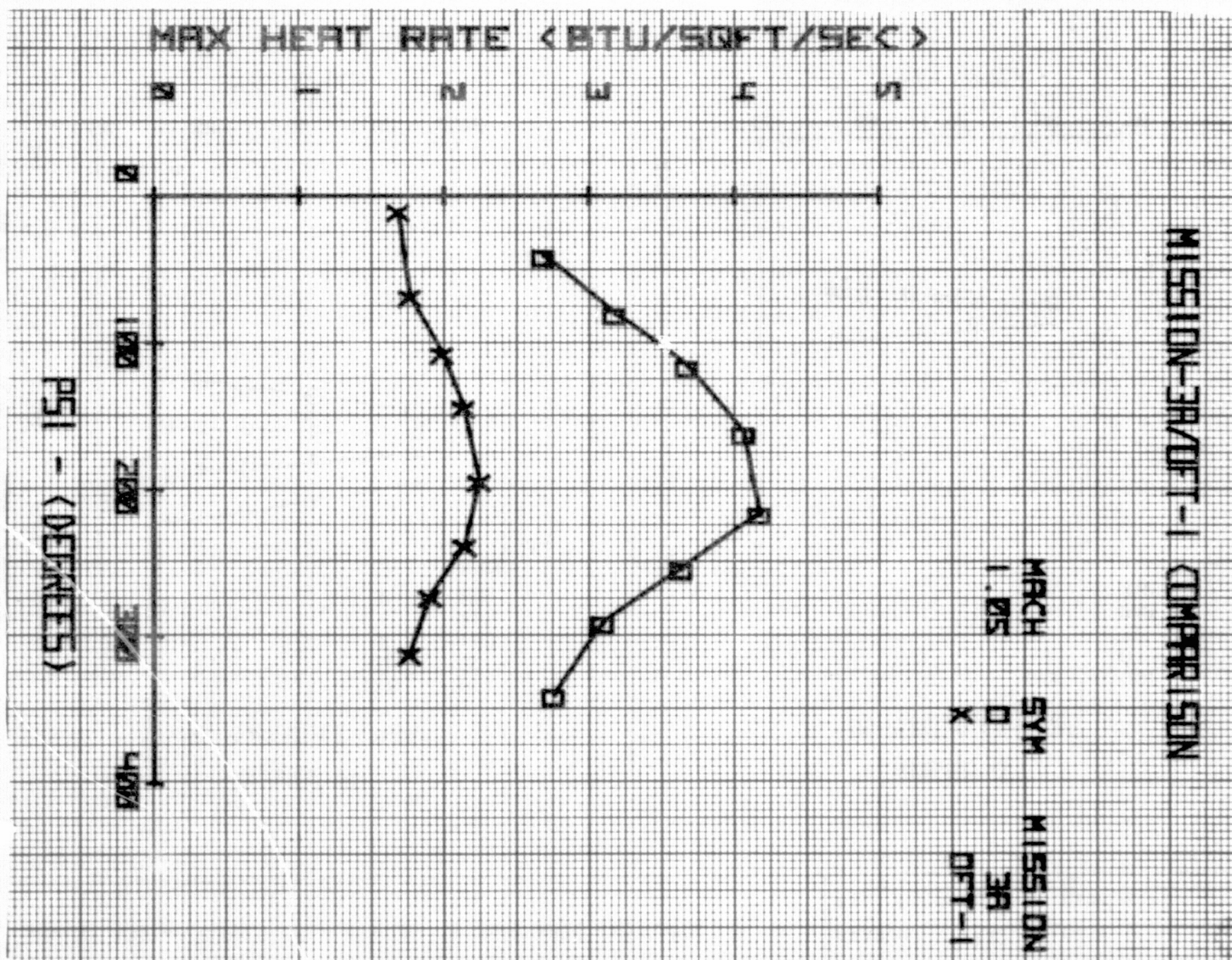


FIGURE 130.- IMPACT OF WINDS ON SSV HEAT RATE INDICATOR

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

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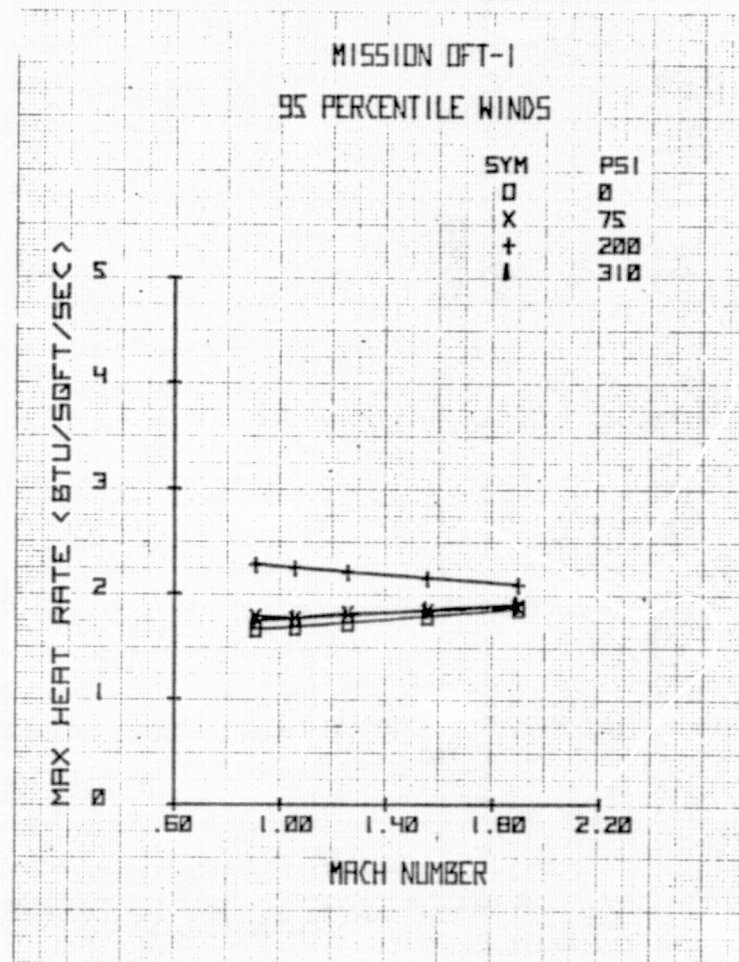
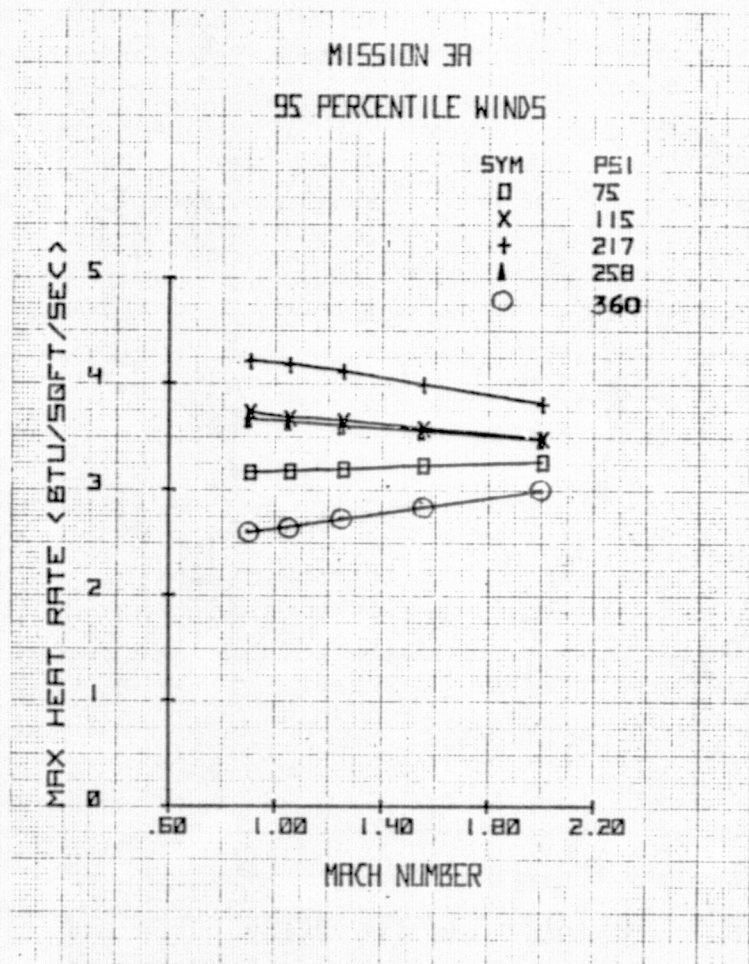


FIGURE 131. - SRB STAGING/95 PERCENTILE WINDS

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE _____

BY L. Austin

PLOT NO. _____

PARAMETER	NOMINAL 3A	WIND EFFECTS	NOMINAL OFT-1	WIND EFFECTS
Q, LB/FT ²	38	± 20	23	± 8
V _R , FT/Sec	4623	± 60	3978	± 60
γ _R , Deg	27.8	± 2.7	39.3	± 2.6
h, Ft	151,318	± 8100	155,521	± 3700
α, Deg	1.13	± .65	1.92	± .65
β, Deg	0.04	± 4	0.11	± 2.6
φ, Deg	180	± 1	180	± 1
P, Deg/Sec	0.14	± .3	0.01	± .2
q, Deg/Sec	0.19	± .2	0.07	± .2
r, Deg/Sec	-0.09	± .15	0.01	± .08

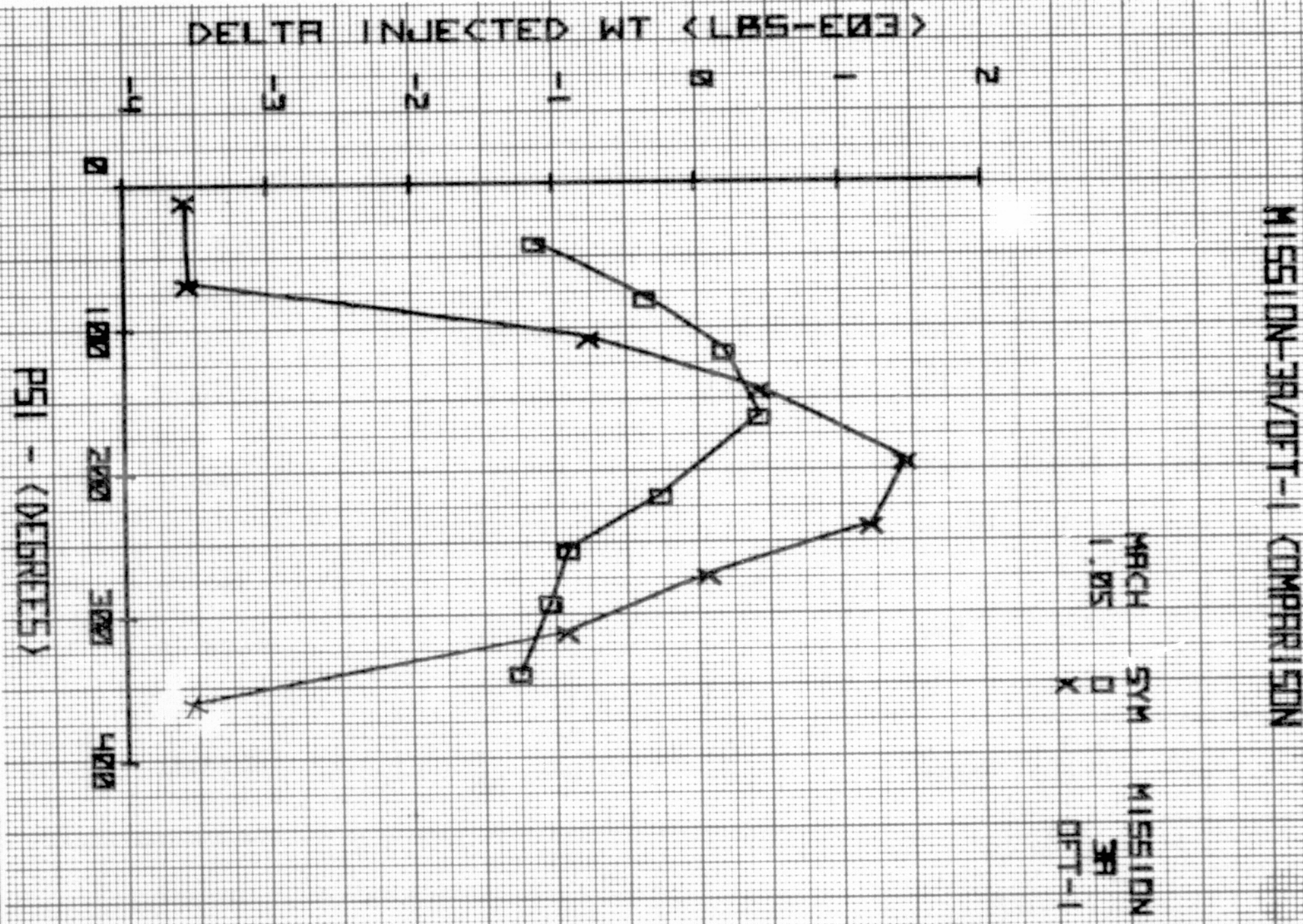
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FIGURE 132.- SSV PERFORMANCE SENSITIVITY TO VARIATIONS
IN WIND DIRECTION

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.



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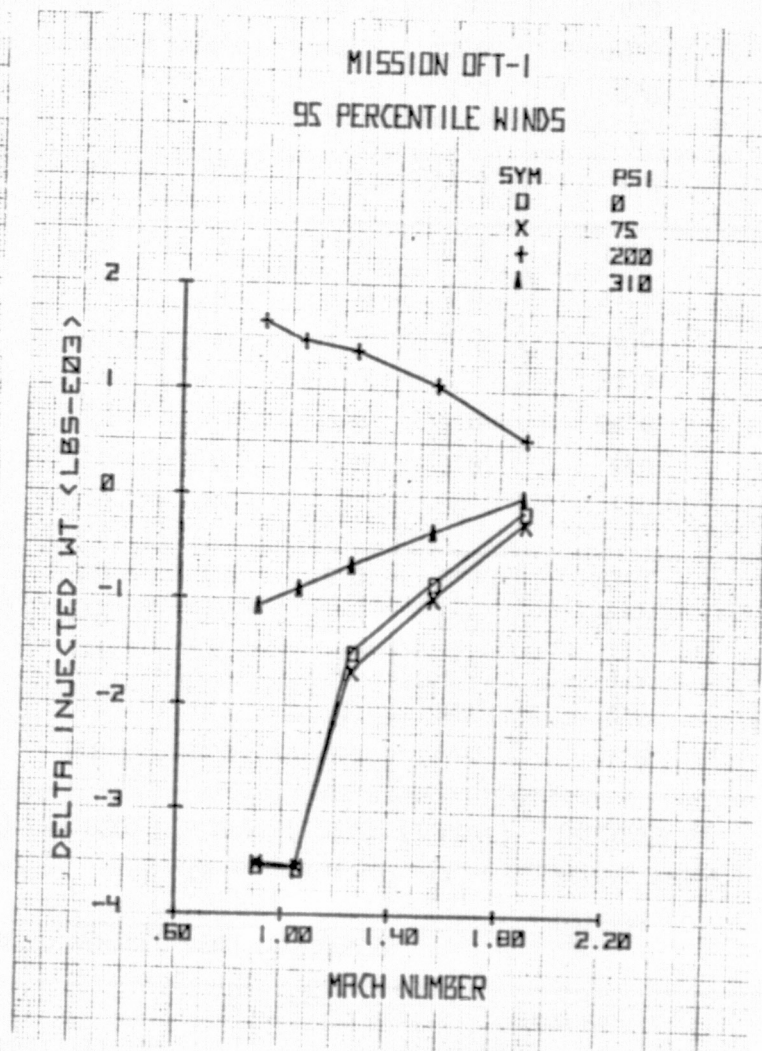
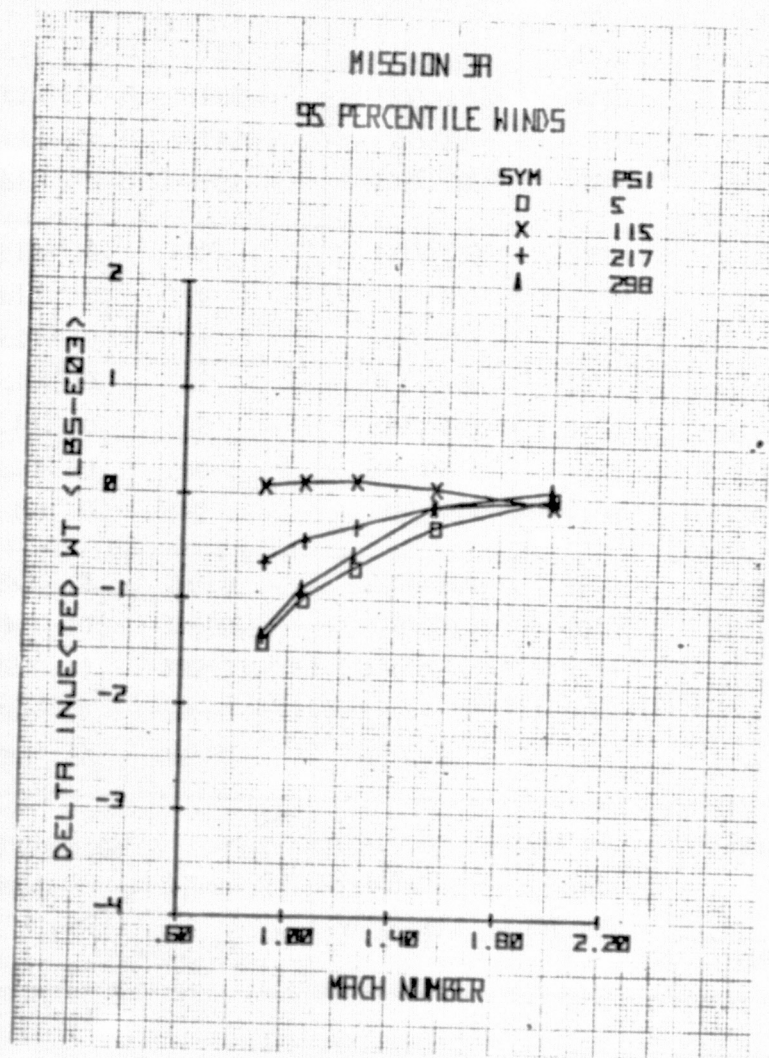
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FIGURE 133.- IMPACT OF WINDS ON SSV PERFORMANCE

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FIGURE 134.- TYPICAL 3A STRUCTURAL LOAD INDICATOR SENSITIVITIES

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DISPERSION LOAD INDICATOR	ALLOWABLE RANGE	SRB WEB TIME ($\pm 4.9\%$)	MATED VEHICLE AERO TOLERANCES					LATERAL ACCEL. ERROR (± 0.0269 g)
			C_N (± 0.047)	C_y (± 0.020)	C_m (± 0.017)	C_n (± 0.013)	C_ℓ (± 0.0074)	
WRB, 10^6 IN-LB	32/-17	3.2	2.0	0.8	0.4	0.1	0.3	1.0
WRT, 10^6 IN-LB	17/ -	1.4	1.0	0.2	0.2	0	0.1	0.4
WS, 10^3 LBS	190/0	20.0	13.0	6.0	2.5	0	2.0	7.0
HMO, 10^3 IN-LB	415/357	10.0	16.0	25.0	8.0	11.0	6.0	30.0
HMI, 10^3 IN-LB	870/-700	20.0	2.0	23.0	3.0	6.0	6.0	23.0
FT01, 10^3 LBS	119/-143	11.0	3.0	1.0	3.0	0	0	2.0
FT02, 10^3 LBS	91/-86	1.0	0	7.0	0	3.0	1.0	8.0
FT03, 10^3 LBS	315/-463	14.0	18.0	34.0	3.0	7.0	1.0	34.0
FT04, 10^3 LBS	354/-394	21.0	18.0	34.0	3.0	7.0	1.0	34.0
FT06, 10^3 LBS	107/-107	1.0	0	9.0	0	5.0	2.0	6.0
FT07, 10^3 LBS	131/-719	15.5	0	12.0	0	1.0	2.0	11.0
FT08, 10^3 LBS	131/-719	15.5	0	11.0	0	1.0	2.0	10.0
FTB 1,2 10^3 LBS	195/-202	3.0	1.0	2.0	8.0	0	11.0	4.0
FTB 3,4 10^3 LBS	$\pm 232/\pm 84$	3.0	2.0	1.0	0	6.0	0	0
FTB 5,6 10^3 LBS	177/-1600	41.0	2.0	1.0	1.0	1.0	1.0	2.0
FTB 7,8 10^3 LBS	278/-220	12.0	14.0	13.0	14.0	3.0	41.0	19.0
FTB 9,10 10^3 LBS	$\pm 206/\pm 348$	5.0	4.0	2.0	1.0	12.0	0	6.0
MTB 1,2 10^6 IN-LB	$\pm 21.2/\pm 25.3$	0.5	1.1	0.8	0.4	0.2	2.1	1.2

FIGURE 135.- TYPICAL OFT-1 STRUCTURAL LOAD INDICATOR SENSITIVITIES

ENGINEERING ANALYSIS DIVISION/EX

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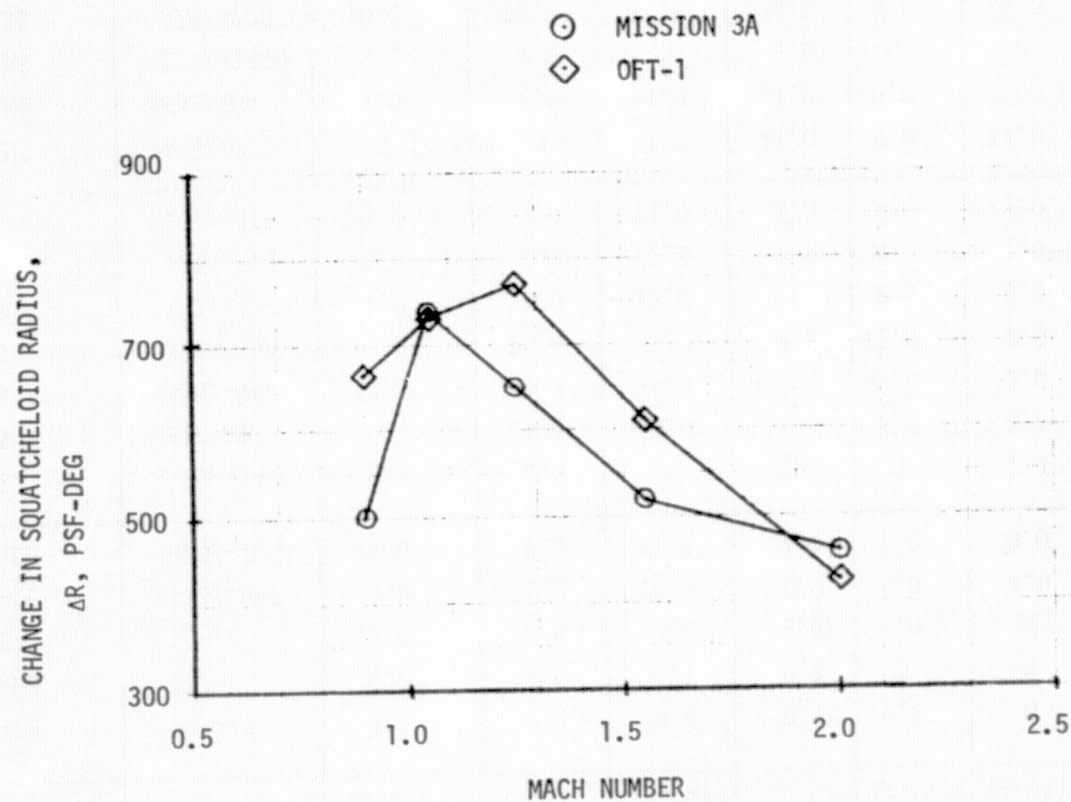
DISPERSION LOAD INDICATOR	ALLOWABLE RANGE	SRB WEB TIME (± 4.9)	MATED VEHICLE AERO TOLERANCES					LATERAL ACCEL. ERROR (± 0.0273 g)
			C_N ($\pm .07$)	C_y ($\pm .032$)	C_m ($\pm .025$)	C_n ($\pm .027$)	C_ℓ ($\pm .0112$)	
WRB, 10^6 IN-LB	32/-17	2.7	2.3	0.4	0.8	0.2	0	0.9
WRT, 10^6 IN-LB	17/ -	1.0	1.0	0.1	0.3	0	0	0
WS, 10^3 LBS	190/0	17.0	14.0	3.0	5.0	1.0	0	6.0
HMO, 10^3 IN-LB	415/-357	9.0	22.0	14.0	16.0	5.0	4.0	18.0
HMI, 10^3 IN-LB	870/-700	25.0	8.0	11.0	7.0	3.0	3.0	11.0
FT01, 10^3 LBS	119/-143	6.5	2.0	0	2.0	0	1.0	2.0
FT02, 10^3 LBS	91/-86	0	1.0	8.0	1.0	6.0	2.0	5.0
FT03, 10^3 LBS	315/-463	12.0	24.0	36.0	2.0	19.0	3.0	19.0
FT04, 10^3 LBS	354/-394	15.0	16.0	30.0	4.0	16.0	2.0	28.0
FT06, 10^3 LBS	107/-107	1.0	1.0	10.0	0	2.0	2.0	4.5
FT07, 10^3 LBS	131/-719	15.0	2.0	12.0	1.0	4.0	1.0	9.0
FT08, 10^3 LBS	131/-719	15.0	1.0	11.0	1.0	2.0	1.0	6.0
FTB 1,2 10^3 LBS	195/-202	0	0	1.0	11.0	5.0	14.0	2.0
FTB 3,4 10^3 LBS	$\pm 232/\pm 84$	1.0	2.0	1.0	1.0	8.0	0	0
FTB 5,6 10^3 LBS	177/-1600	9.0	4.0	0	3.0	0	0	1.0
FTB 7,8 10^3 LBS	278/-220	10.0	25.0	13.0	25.0	9.0	55.0	6.0
FTB 9,10 10^3 LBS	$\pm 206/\pm 348$	6.0	4.0	2.0	2.0	21.0	0	6.0
MTB 1,2 10^6 IN-LB	$\pm 21.2/\pm 25.3$	0.3	2.0	0.8	1.0	0.6	2.9	1.0

FIGURE 136.- IMPACT OF MATED VEHICLE DISPERSIONS ON
SQUATCHELOID SIZE

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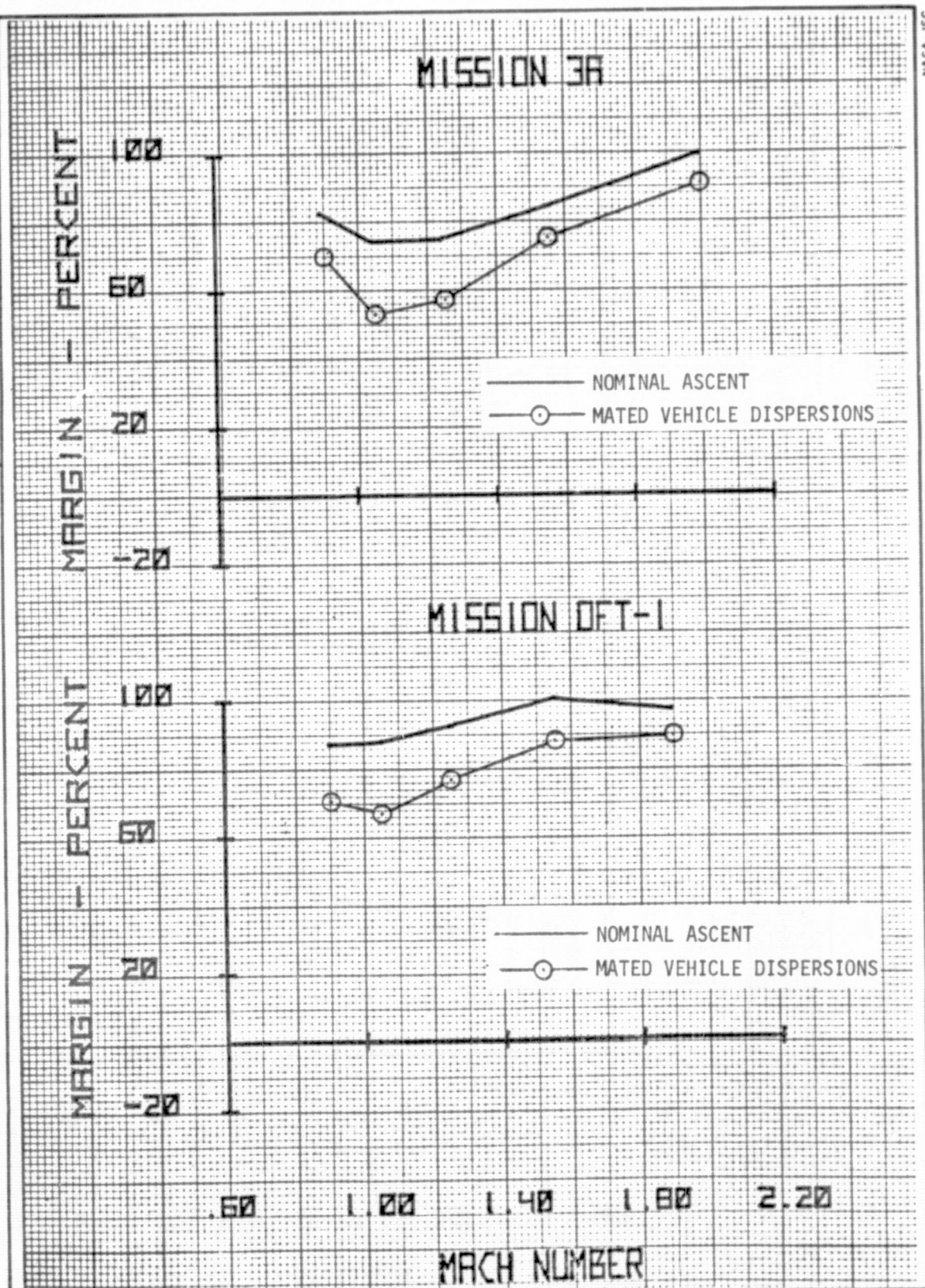


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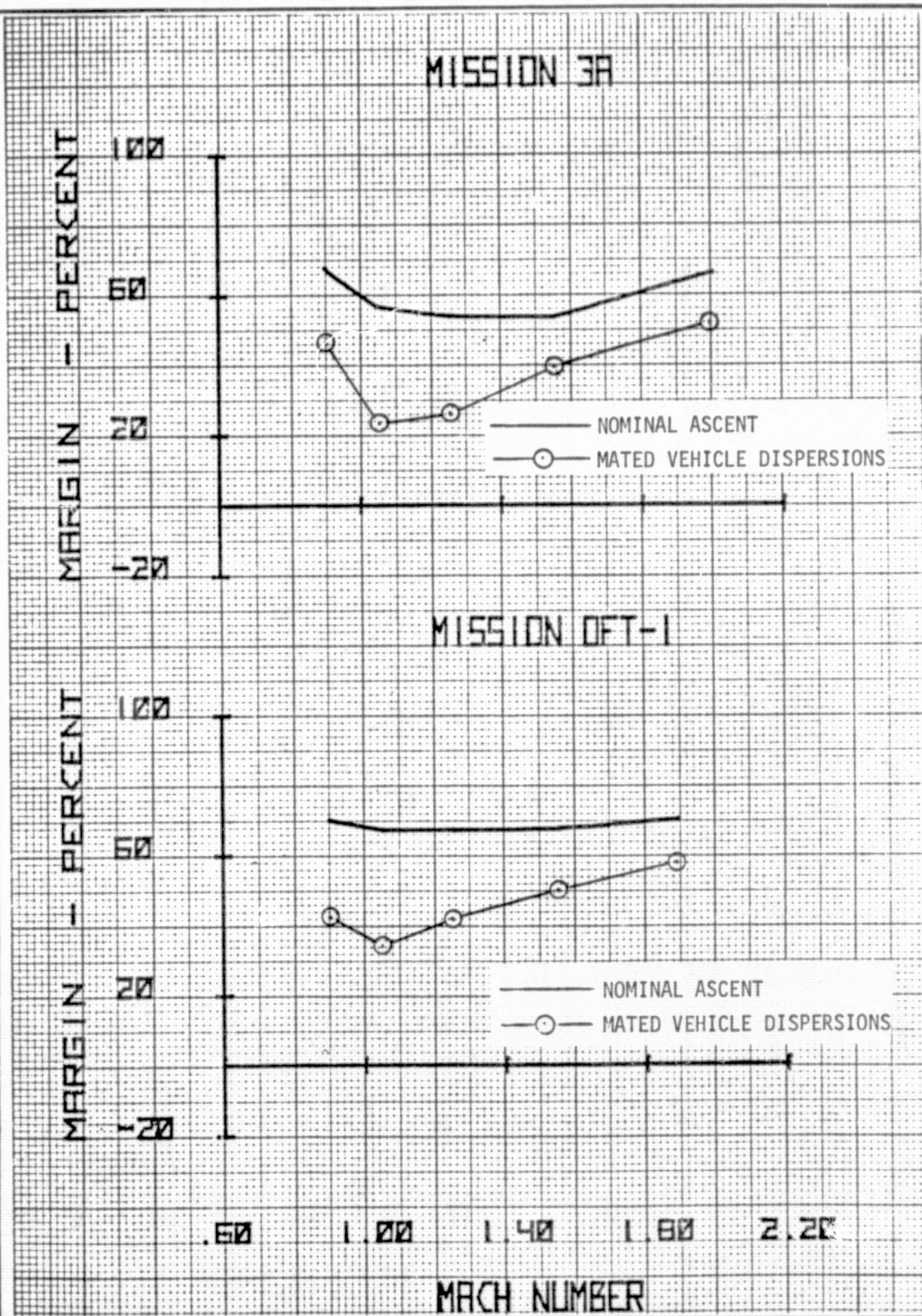
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FIGURE 137.- IMPACT OF DISPERSIONS/WING ROOT BENDING



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FIGURE 133.- IMPACT OF DISPERSIONS/WING SHEAR



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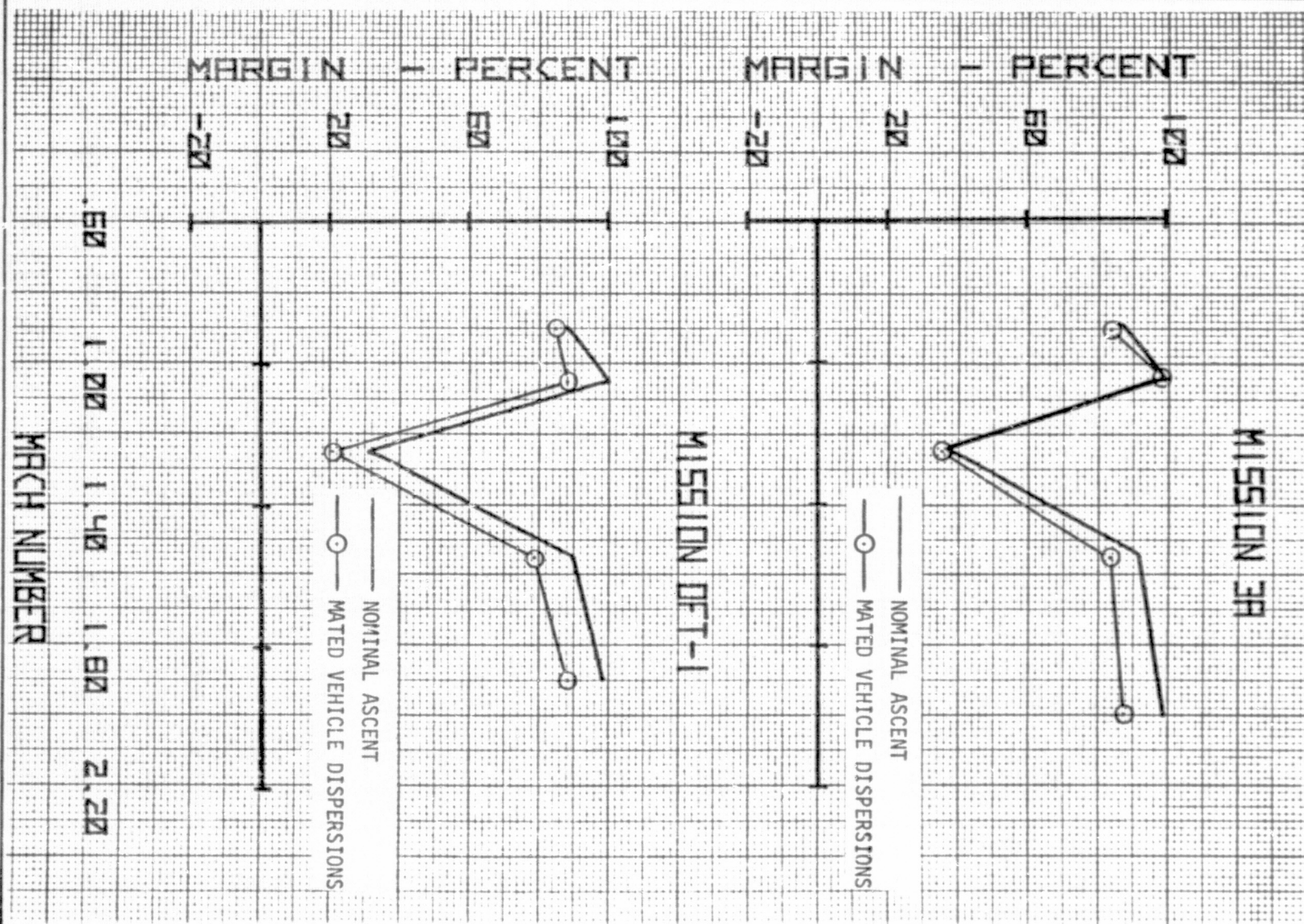
JSC FORM 1138 (MAR 73)

FIGURE 139.- IMPACT OF DISPERSIONS/OUTBOARD ELEVON HINGE MOMENT

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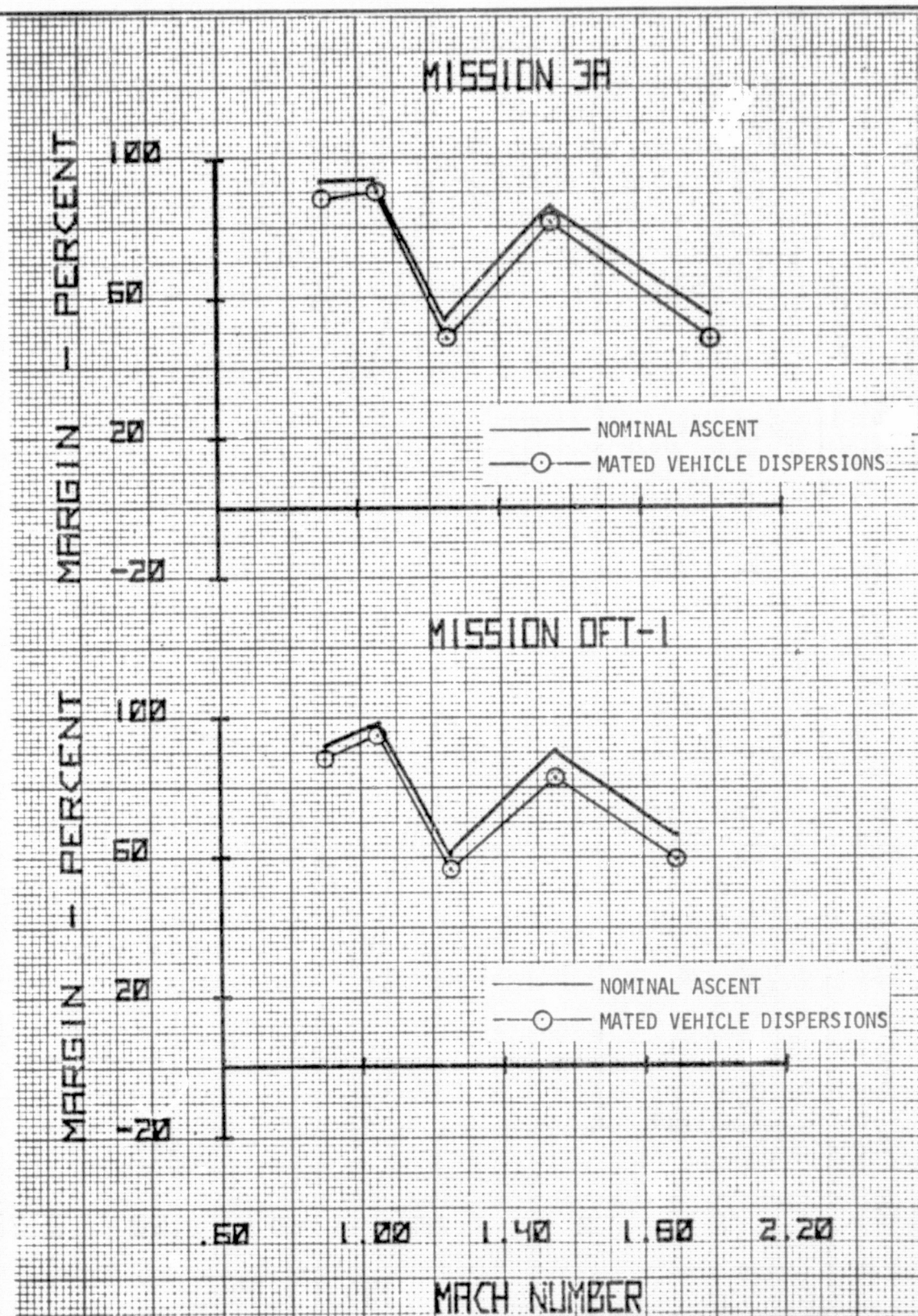


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FIGURE 140.- IMPACT OF DISPERSIONS/INBOARD ELEVON HINGE MOMENT



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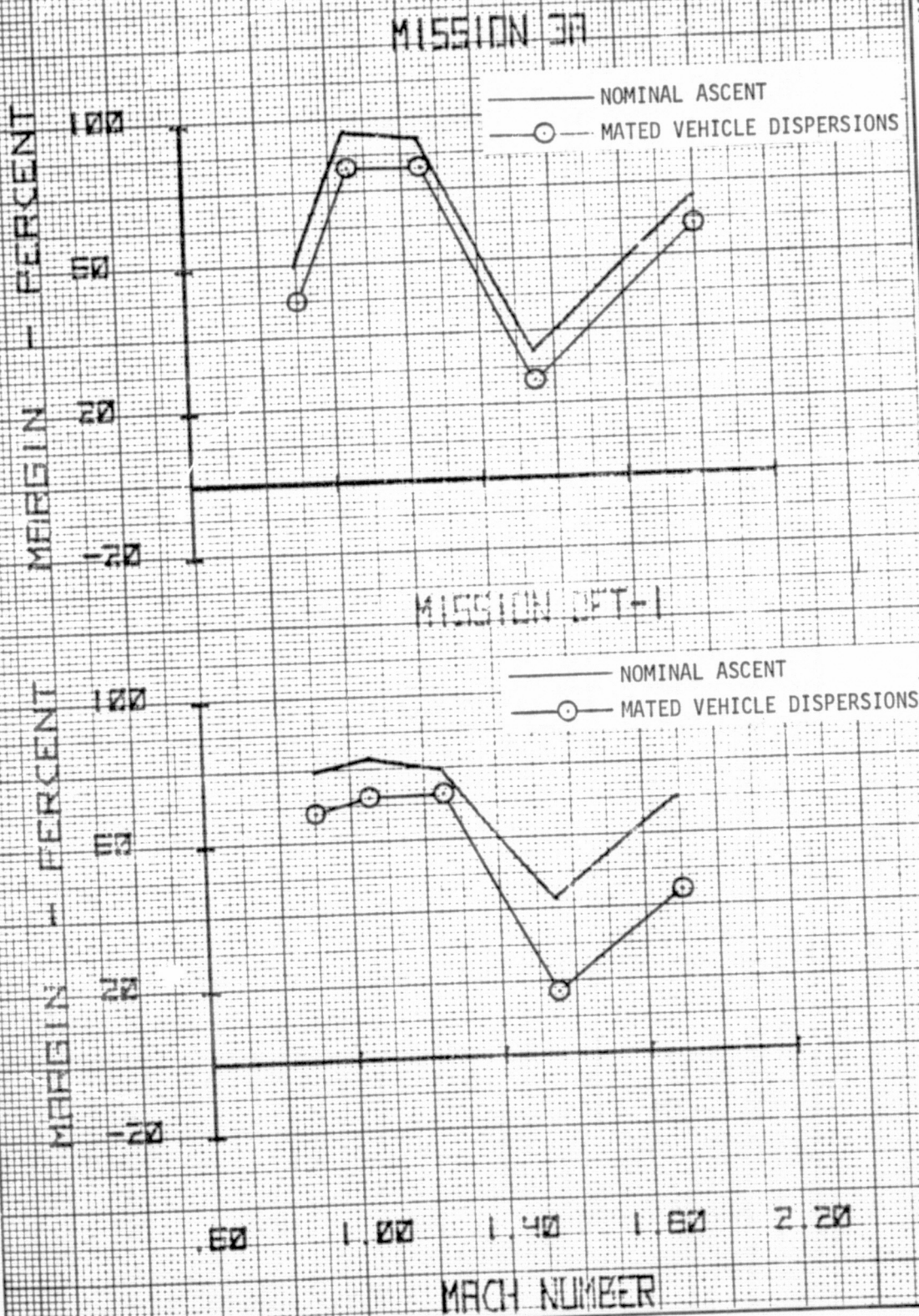
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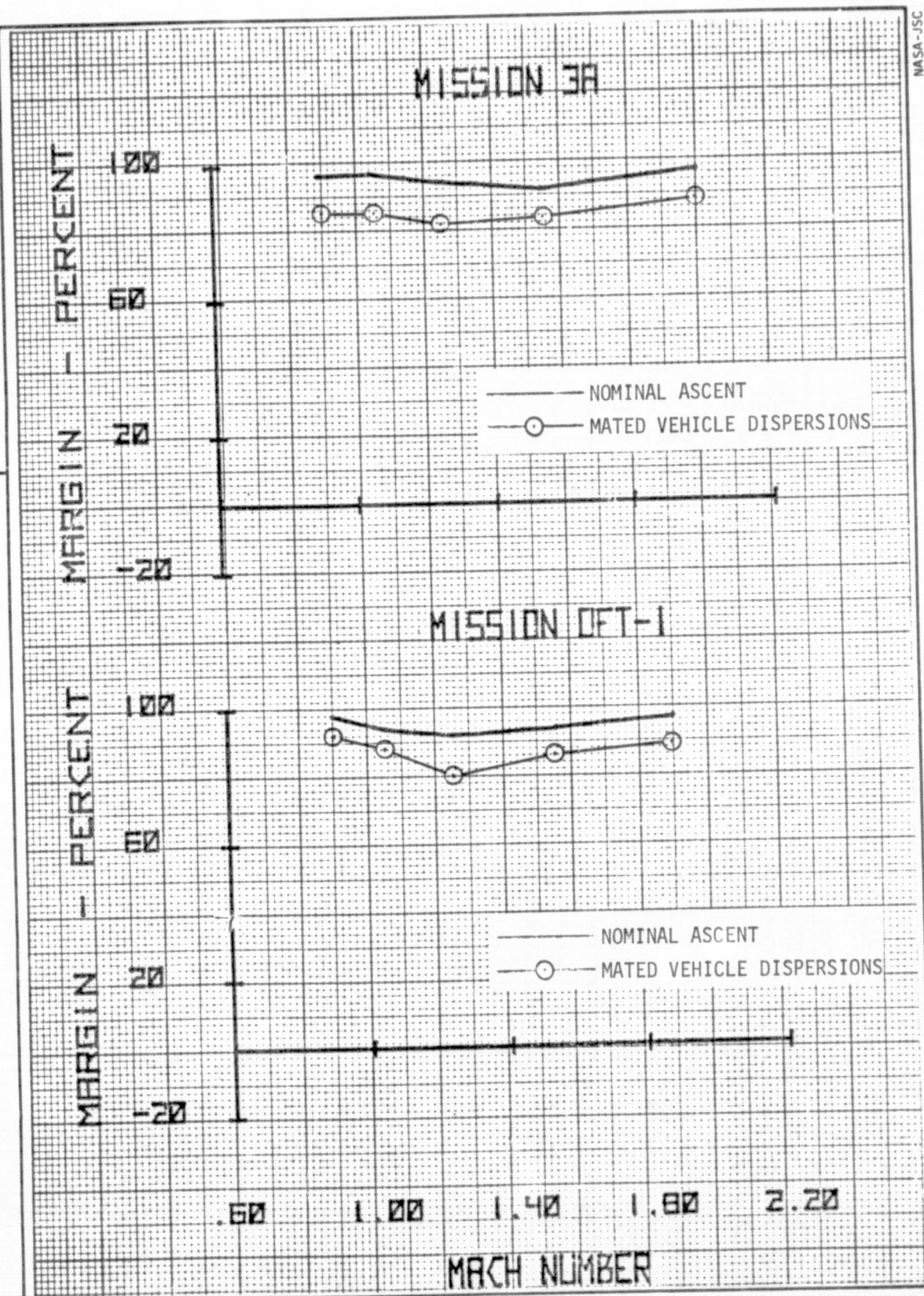
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FIGURE 141.- IMPACT OF DISPERSIONS/FT01



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FIGURE 142.- IMPACT OF DISPERSIONS/FT02



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FIGURE 143.- IMPACT OF DISPERSIONS/FT03

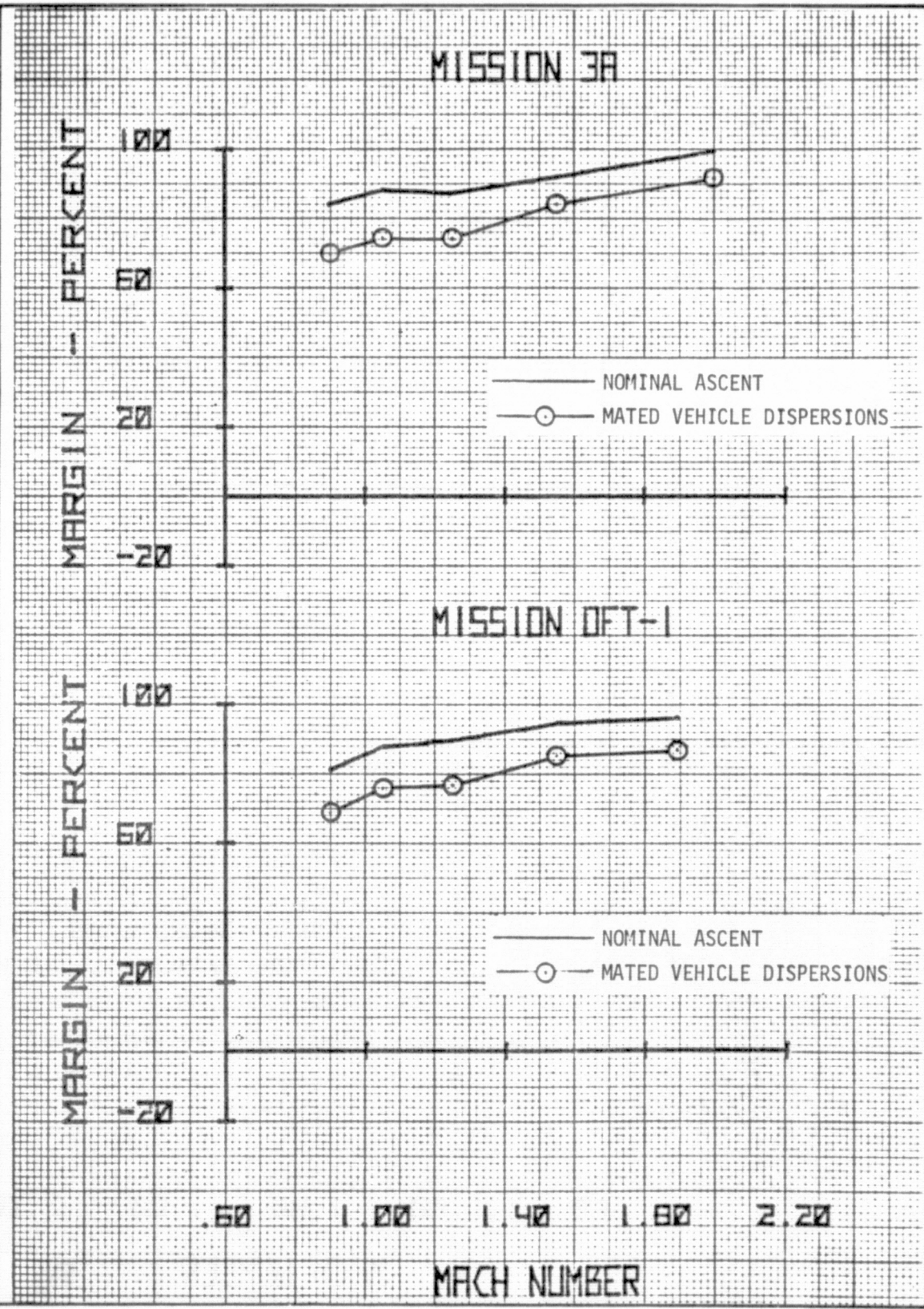
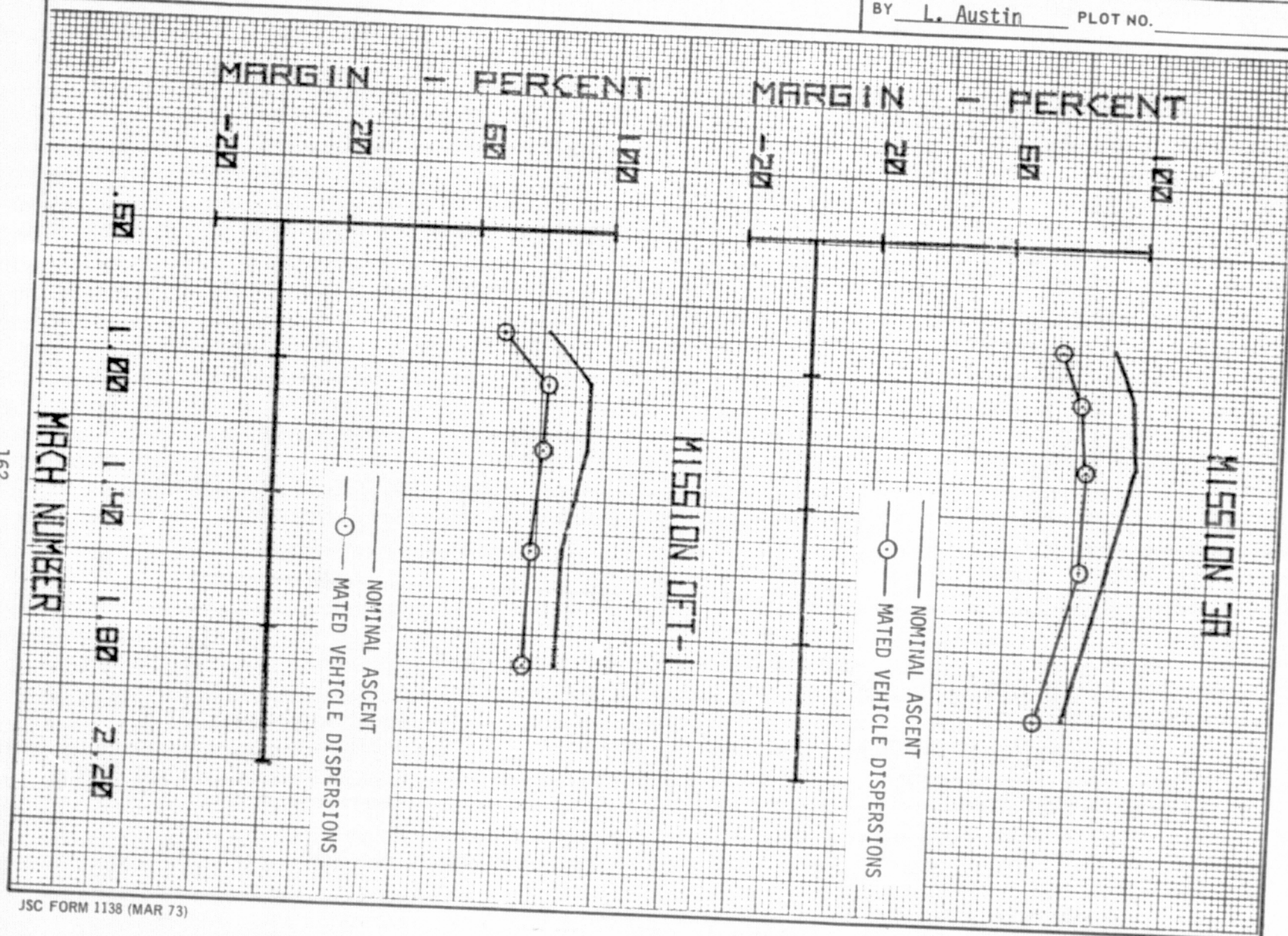


FIGURE 144.- IMPACT OF DISPERSIONS/FT04

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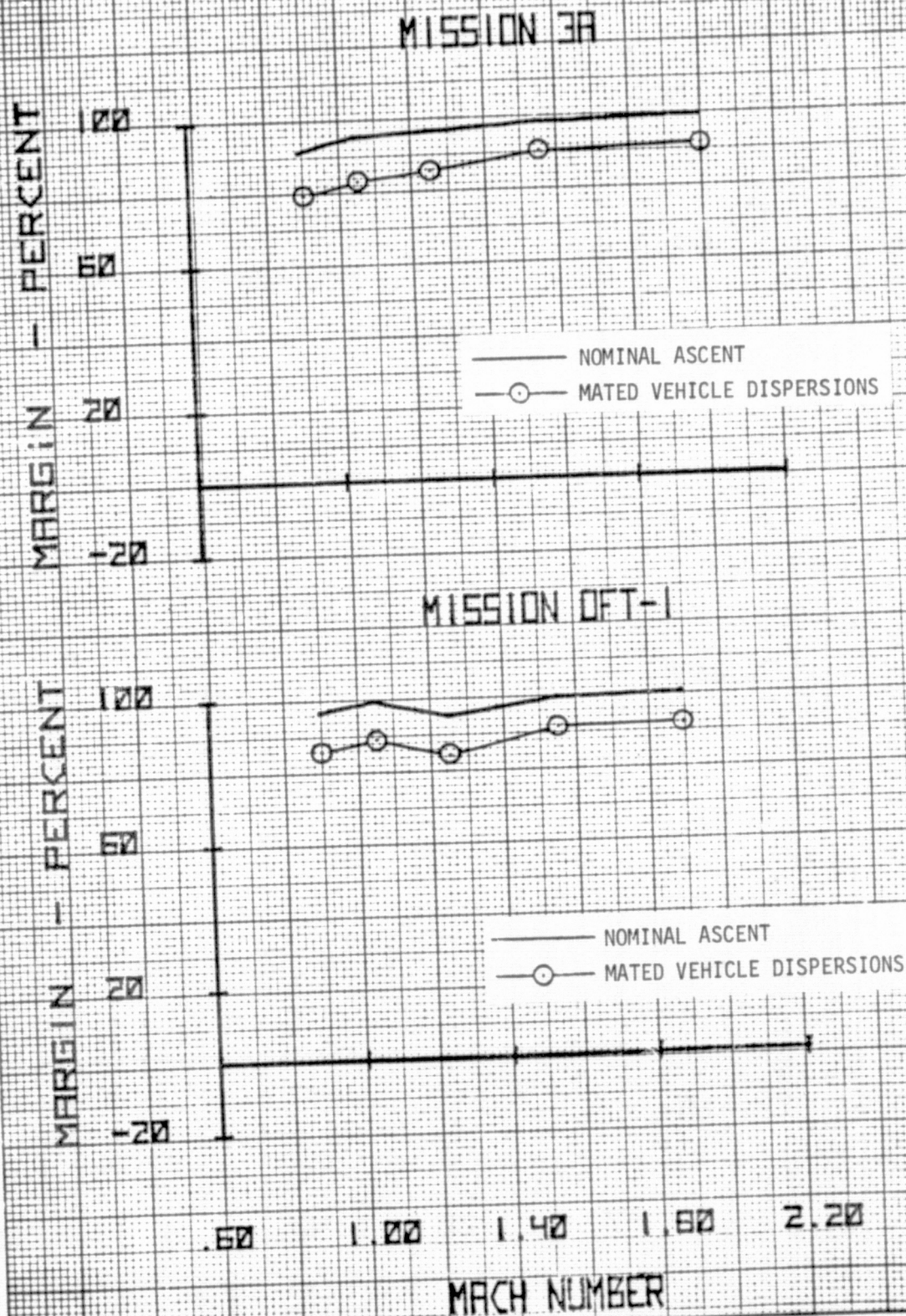


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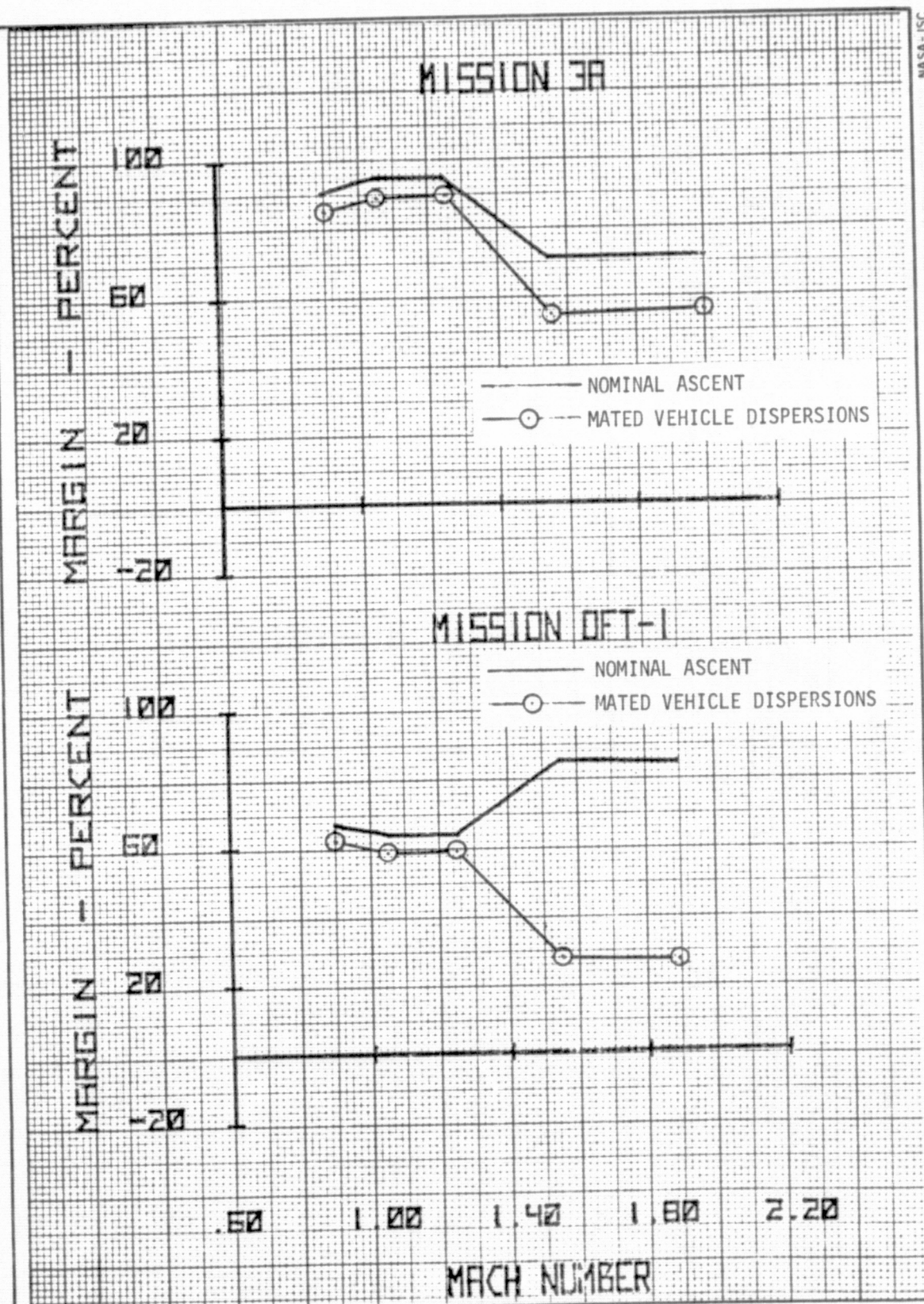
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FIGURE 145.- IMPACT OF DISPERSIONS/FT06



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FIGURE 146.- IMPACT OF DISPERSIONS/FT07

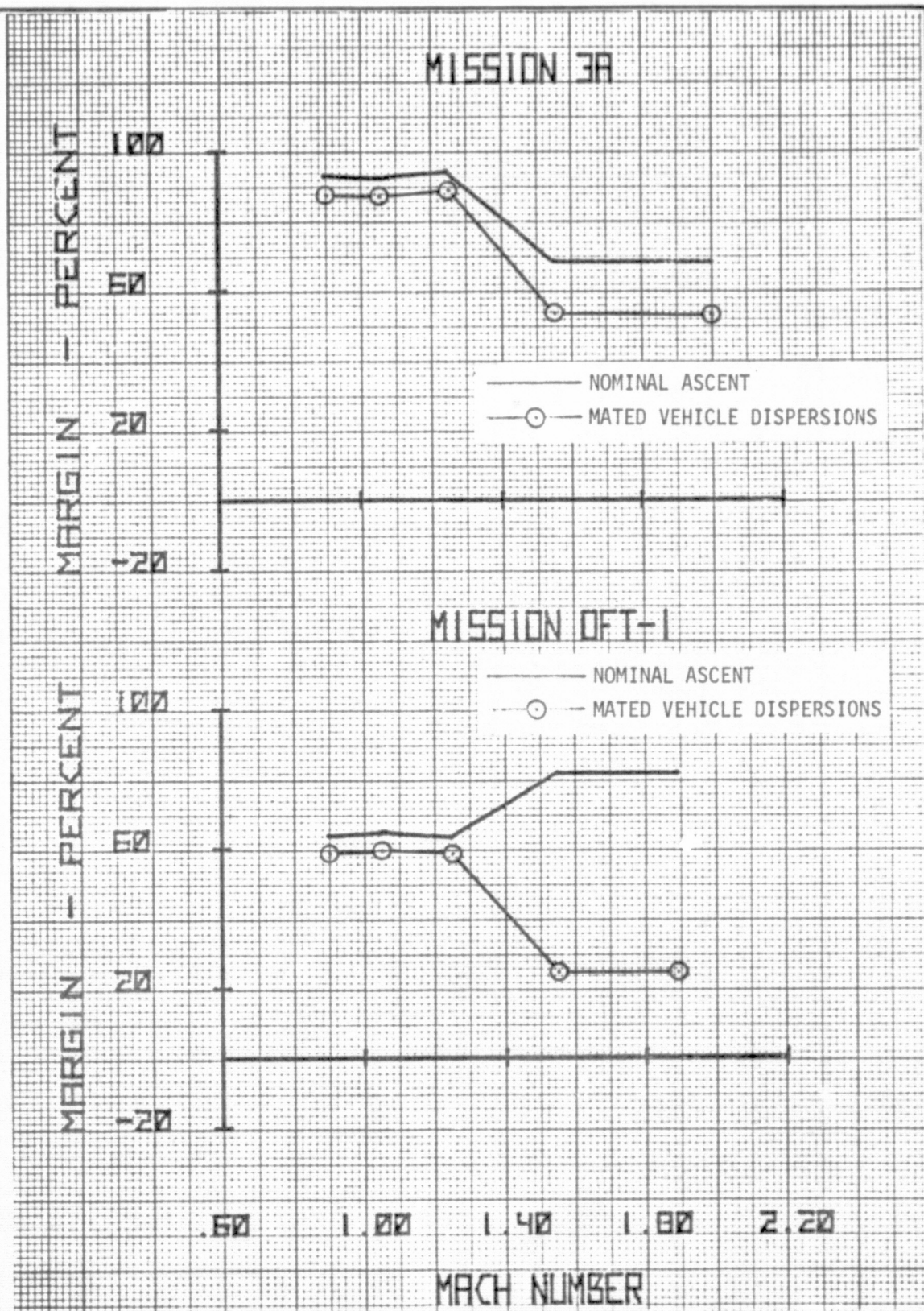


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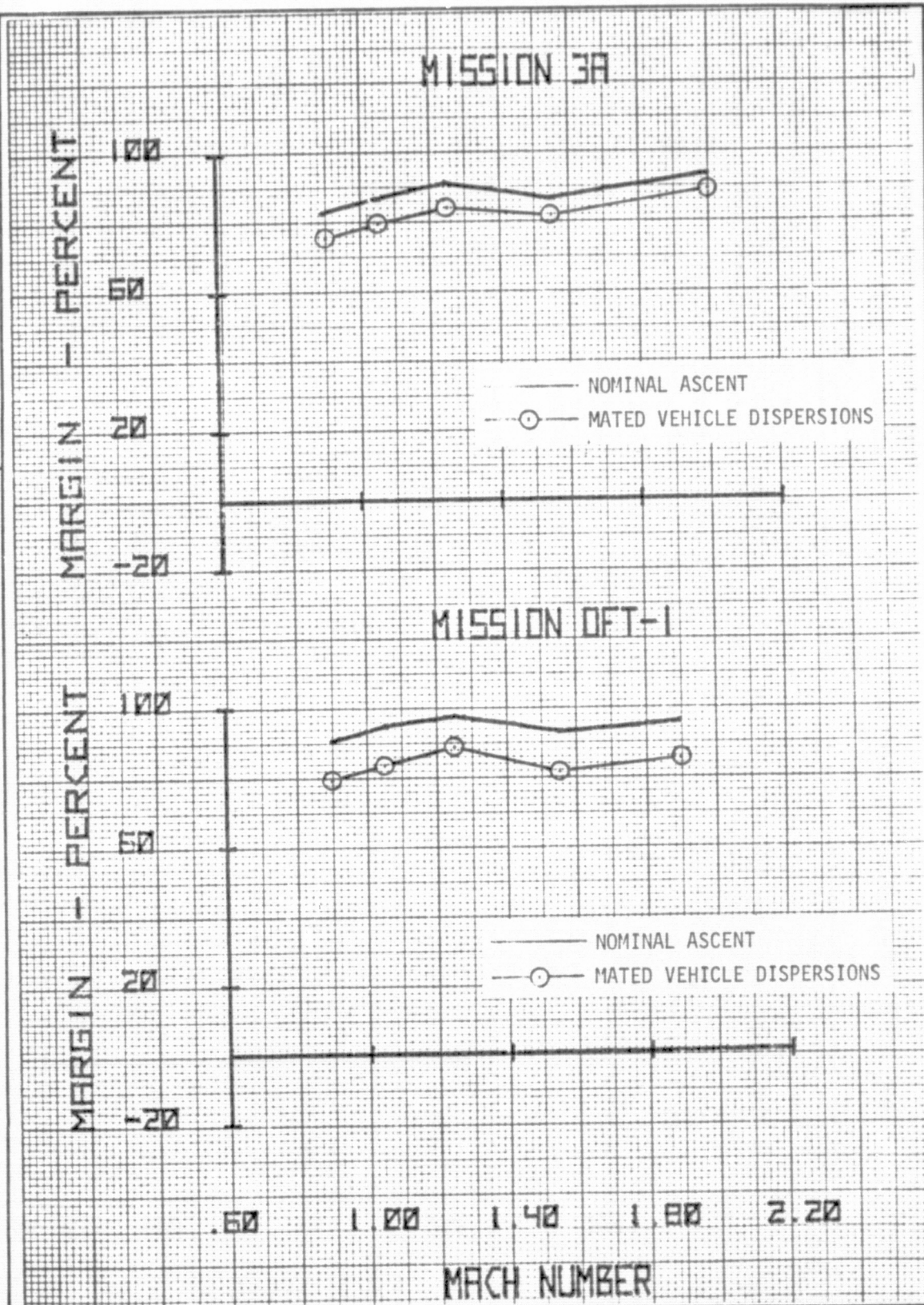
FIGURE 147.- IMPACT OF DISPERSIONS/FT08



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FIGURE 148.- IMPACT OF DISPERSIONS/FTB 1,2



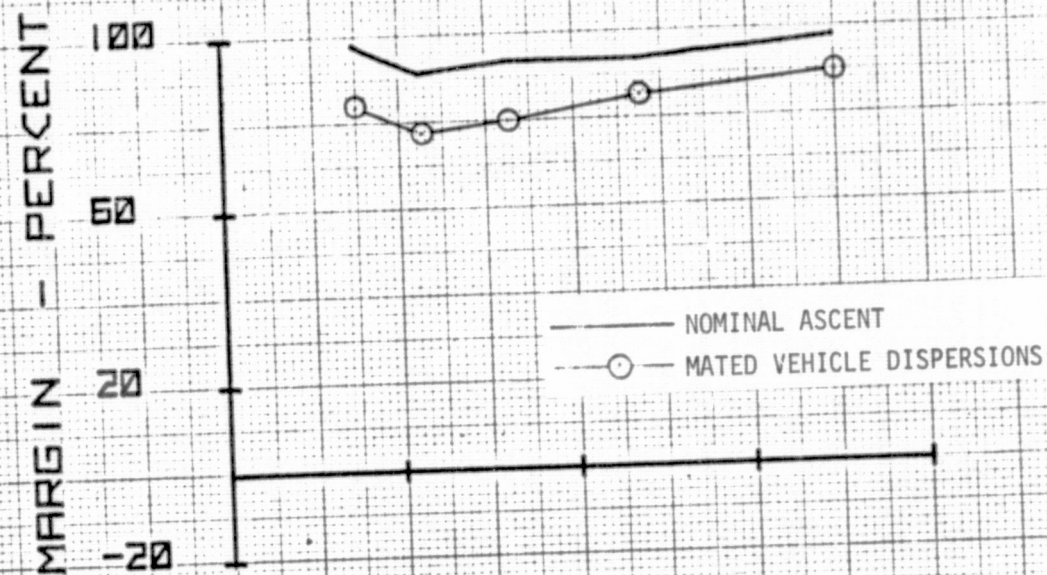
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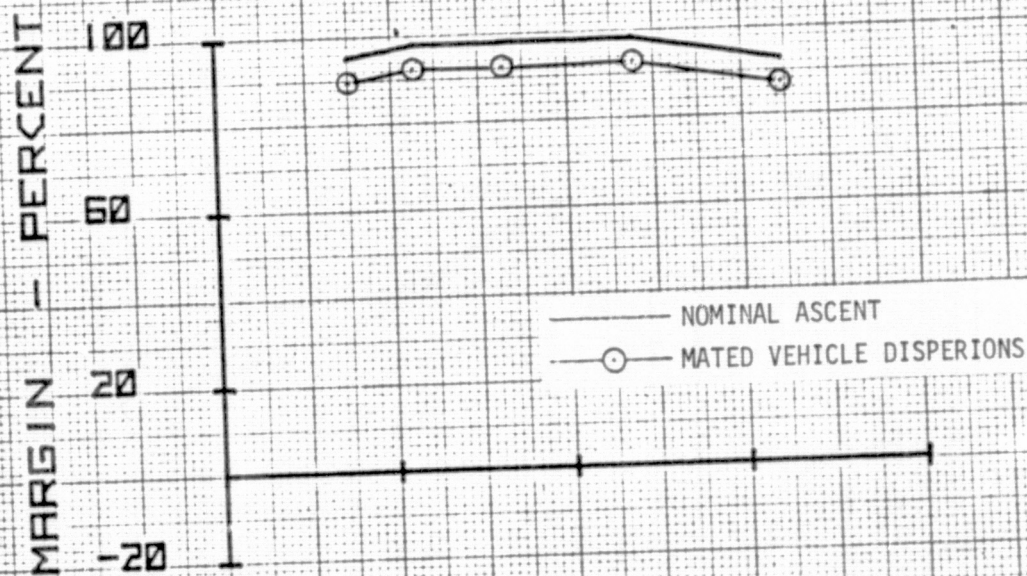
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FIGURE 149.- IMPACT OF DISPERSIONS/FTB 3,4

MISSION 3A



MISSION DFT-1



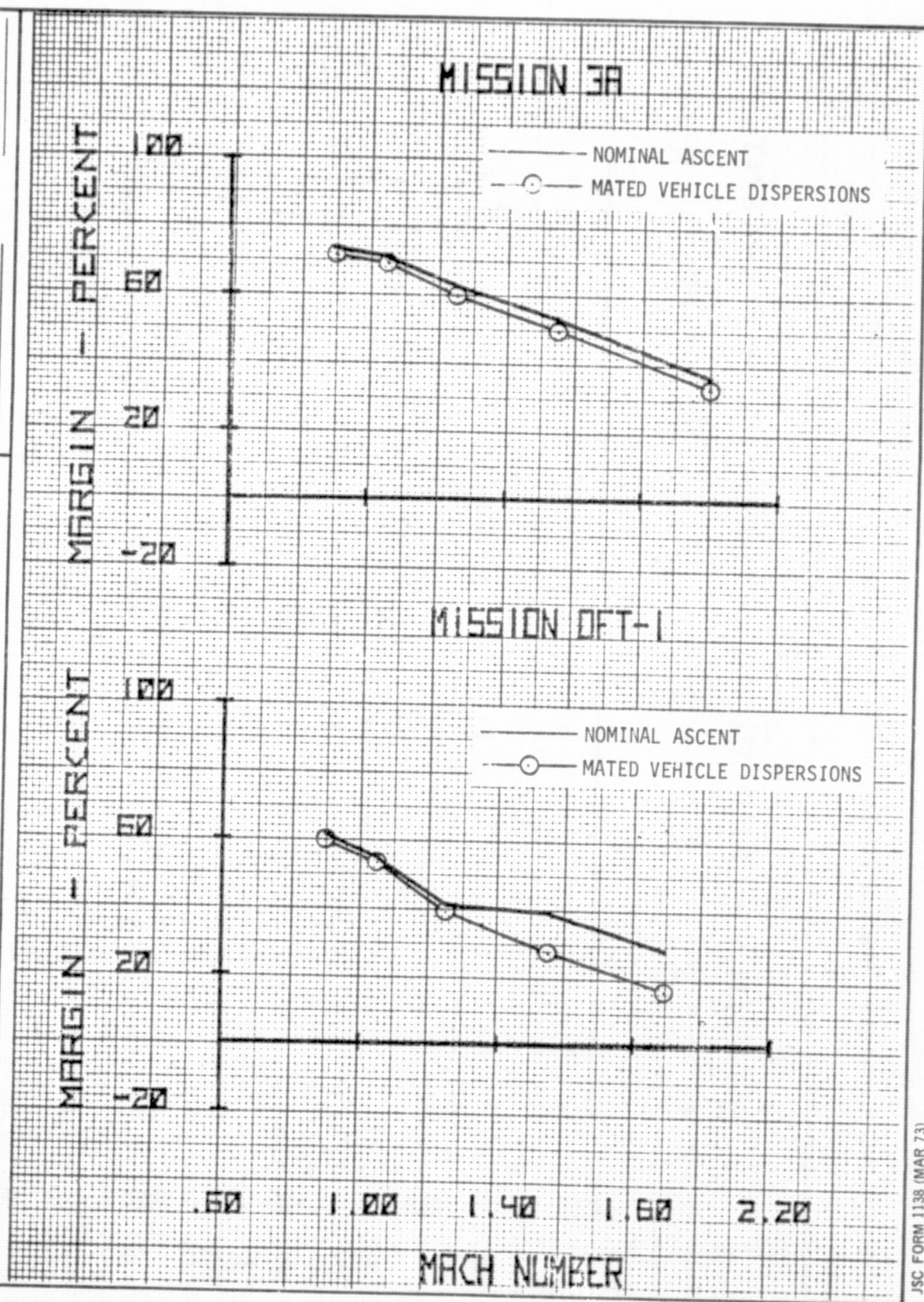
MACH NUMBER

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FIGURE 150.- IMPACT OF DISPERSIONS/FTB 5,6



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FIGURE 151.- IMPACT OF DISPERSIONS/FTO 7,8

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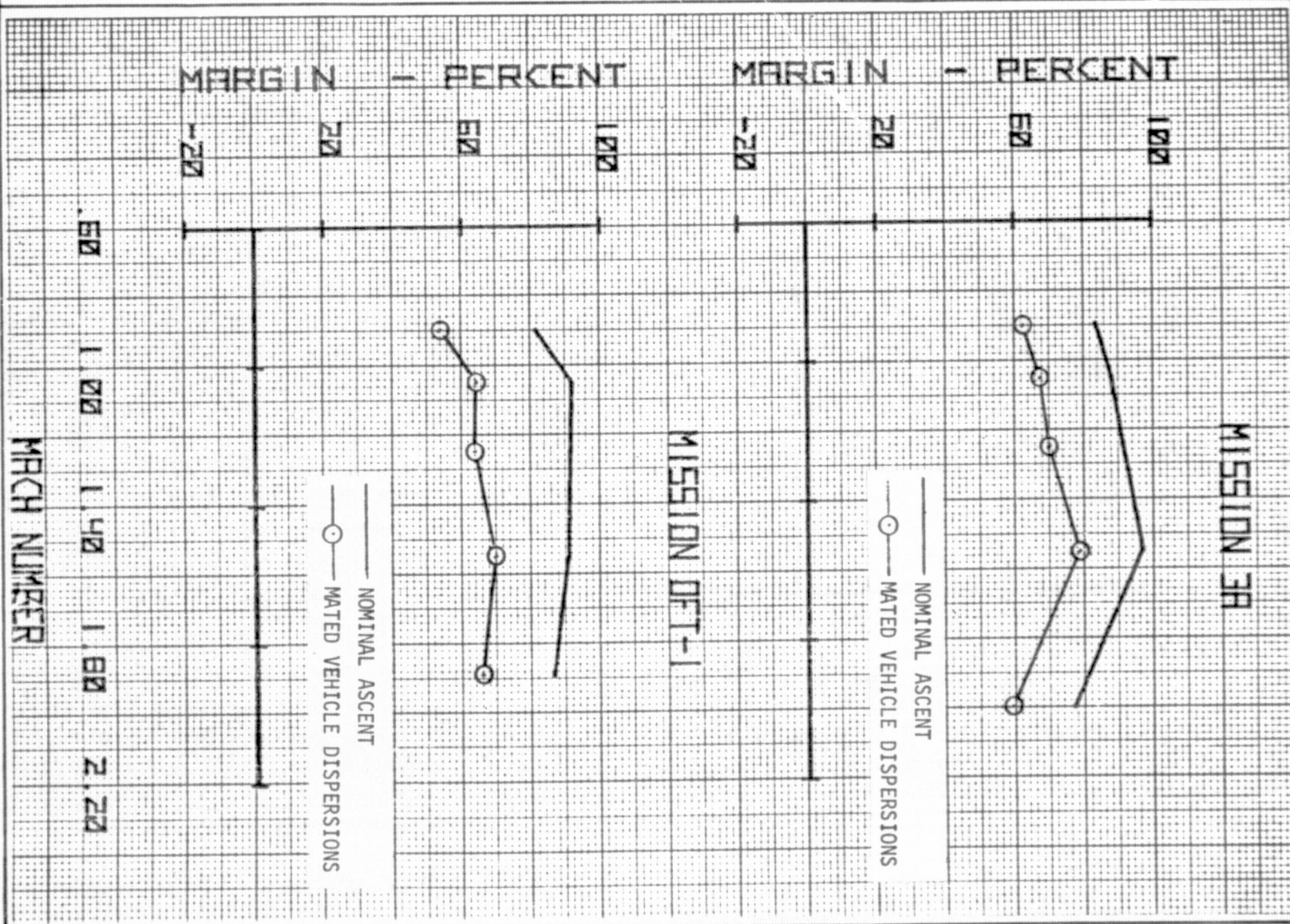
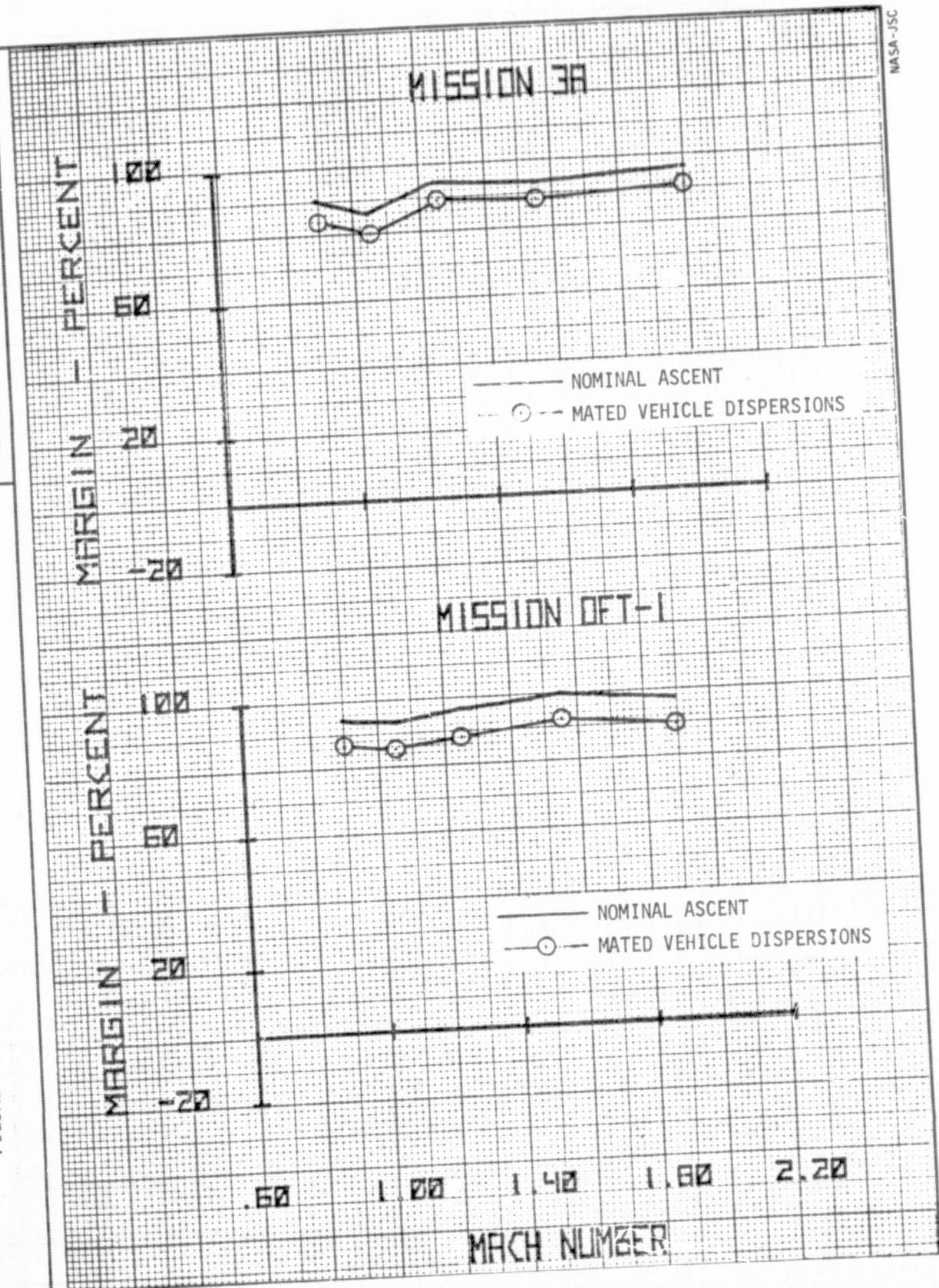


FIGURE 152.- IMPACT OF DISPERSIONS/FTB 9,10



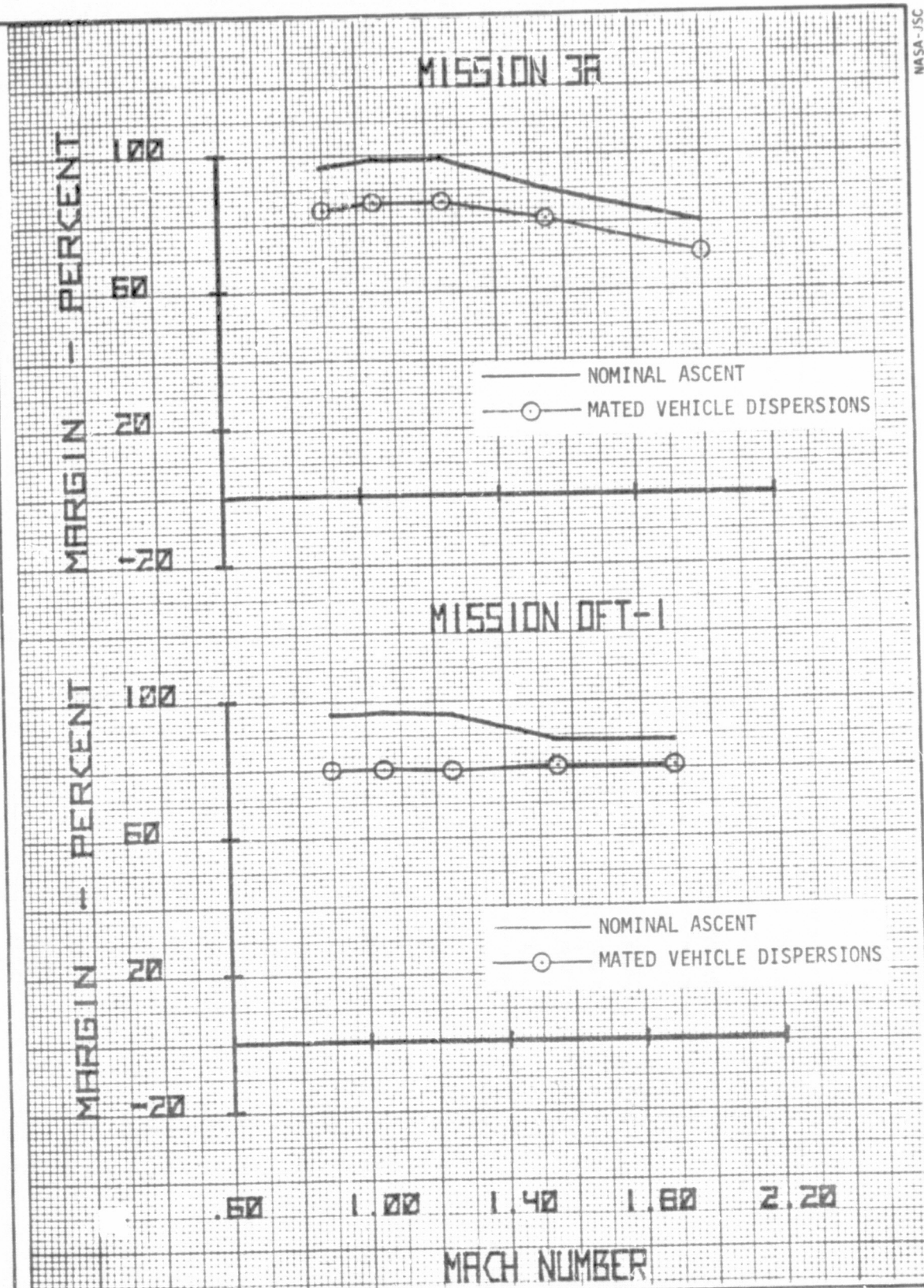
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FIGURE 153.- IMPACT OF DISPERSIONS/MTB 1,2



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FIGURE 154.- MINIMUM MARGINS (%) / 3A SYSTEMS DISPERSIONS

ENGINEERING ANALYSIS DIVISION/EX

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LOAD INDICATOR	NOMINAL	DISPERSIONS
WRB	74	53
WS	54	23
HMO	37	35
HMI	54	48
FT01	35	26
FT02	92	82
FT03	84	70
FT04	78	70
FT06	91	80
FT07	71	55
FT08	68	53
FTB1, 2	83	75
FTB3, 4	91	77
FTB5, 6	36	33
FTB7, 8	77	59
FTB9, 10	86	80
MTB1, 2	81	71

NOTE: $0.9 \leq \text{MACH} \leq 2.0$

FIGURE 155.- MINIMUM MARGINS (%) /OFT-1 SYSTEMS DISPERSIONS

ENGINEERING ANALYSIS DIVISION/EX

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LOAD INDICATOR	NOMINAL	DISPERSIONS
WRB	87	67
WS	67	34
HMO	31	20
HMI	61	56
FT01	43	17
FT02	92	80
FT03	81	69
FT04	81	68
FT06	94	84
FT07	64	28
FT08	64	25
FTB1, 2	90	80
FTB3, 4	93	87
FTB5, 6	28	16
FTB7, 8	81	54
FTB9, 10	93	85
MTB1, 2	88	80

NOTE: $0.9 \leq \text{MACH} \leq 2.0$

FIGURE 156. - MISSION 3A MINIMUM INDICATOR MARGINS

ENGINEERING ANALYSIS DIVISION/EX

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LOAD INDICATOR	NOMINAL MEAN WIND	95 PERCENTILE VECTOR WINDS	WINDS AND DISPERSIONS
WRB	74	27	23
WS	54	16	5
HMO	37	3	3
HMT	54	42	40
FT01	35	34	25
FT02	92	51	50
FT03	84	37	35
FT04	78	44	43
FT06	91	60	58
FT07	71	62	53
FT08	68	55	48
FTB1, 2	83	82	75
FTB3, 4	91	79	73
FTB5, 6	36	34	32
FTB7, 8	77	38	34
FTB9, 10	86	73	72
MTB1, 2	81	58	46

Note: $0.9 \leq \text{Mach No.} \leq 2.0$

FIGURE 157. - OFT-1 MINIMUM INDICATOR MARGINS

ENGINEERING ANALYSIS DIVISION/EX

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LOAD INDICATOR	NOMINAL MEAN WIND	95 PERCENTILE VECTOR WINDS	WINDS AND DISPERSIONS
WRB	87	40	36
WS	67	28	16
HMO	31	5	3
HMI	61	52	51
FT01	43	43	17
FT02	92	54	52
FT03	81	44	42
FT04	81	40	38
FT06	94	70	68
FT07	64	52	26
FT08	64	52	23
FTB1, 2	90	87	80
FTB3, 4	93	91	87
FTB5, 6	28	26	16
FTB7, 8	81	37	29
FTB9, 10	93	80	78
MTB1, 2	88	57	56

Note: $0.9 \leq M \leq 2.0$

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FIGURE 158. - SSV SYSTEM DISPERSIONS IMPACT

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● FIRST STAGE SSV INDICATORS SUMMARY

MISSION	MAXIMUM DYNAMIC PRESSURE, PSF	MAXIMUM HEAT RATE, BTU/FT ² /SEC	HEAT LOAD BTU/FT ²	LOX BULKHEAD LOAD INDICATOR, LBS
3A	650	3.37	125.01	2,627,000
DISPERSION EFFECT	± 57	± 0.70	± 21	± 140,000
OFT-1	550	1.95	71.3	2,740,000
DISPERSION EFFECT	± 64	± 0.38	± 11	± 140,000

FIGURE 159.- FLUTTER MARGIN/WORST CASE VECTOR WINDS AND DISPERSIONS

ENGINEERING ANALYSIS DIVISION EX

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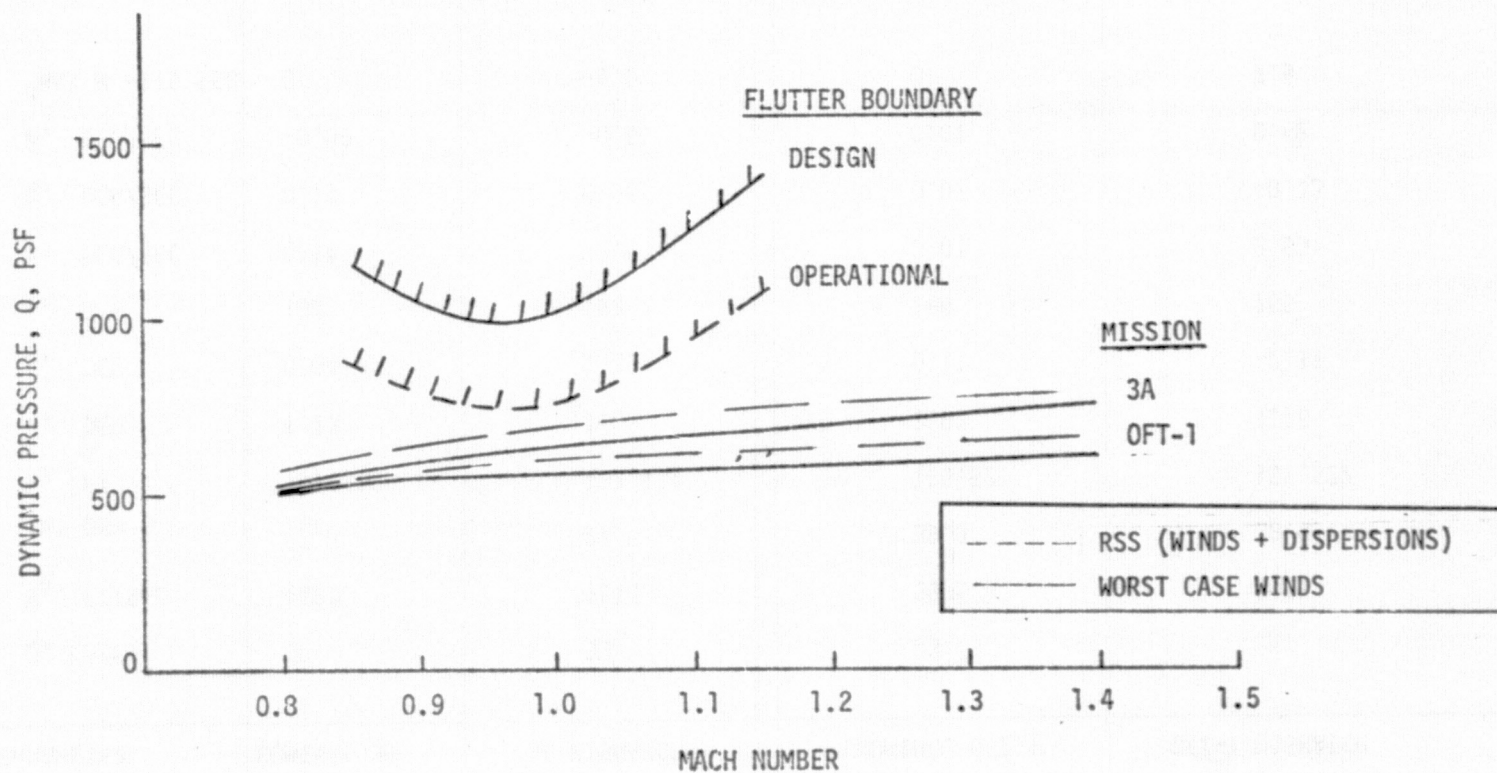


FIGURE 160. - SRB MISMATCH IMPACT ON STAGING

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

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PARAMETER	NOMINAL 3A	3A MISMATCH	NOMINAL OFT-1	OFT-1 MISMATCH
Q, Lb/FT ²	38	35	23	21
V _R , FT/Sec	4623	4615	3978	3975
Y _R , DEG	27.8	27.7	39.3	38.9
h, FT	151,318	153,434	155,521	157,522
α, DEG	1.13	1.06	1.92	1.76
β, DEG	0.04	1.83	0.11	-2.11
φ, DEG	180	193	180	165
p, DEG/SEC	0.14	-3.60	0.01	3.50
q, DEG/SEC	0.19	0.06	0.07	-0.13
r, DEG/SEC	-0.09	-0.55	0.01	0.62
β _{MAX} @ ≈115 SEC	0	-5.0	0	7.5

FIGURE 161. - IMPACT OF DISPERSIONS ON SRB STAGING

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

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PARAMETER	NOMINAL 3A	DISPER:SION EFFECTS	NOMINAL OFT-1	DISPERSION EFFECTS
Q, LB/FT ²	38	± 19	23	± 10
V _R , FT/SEC	4623	± 94	3978	± 75
γ_R , DEG	27.8	± 4	39.3	± 3
h, FT	151,318	± 8150	155,521	± 6000
α , DEG	1.13	± 2.4	1.92	± 3.6
β , DEG	0.04	± 2.5	0.11	± 3.1
ϕ , DEG	180	± 16	180	± 15
p, DEG/SEC	0.14	± 4.0	0.01	± 4.0
q, DEG/SEC	0.10	± 0.4	0.07	± 0.4
r, DEG/SEC	-0.09	± 0.6	0.01	± 0.7

FIGURE 162.- IMPACT OF SRB MISMATCH ON HYDRAULIC FLOW REQUIREMENTS/3A

ENGINEERING ANALYSIS DIVISION/EX

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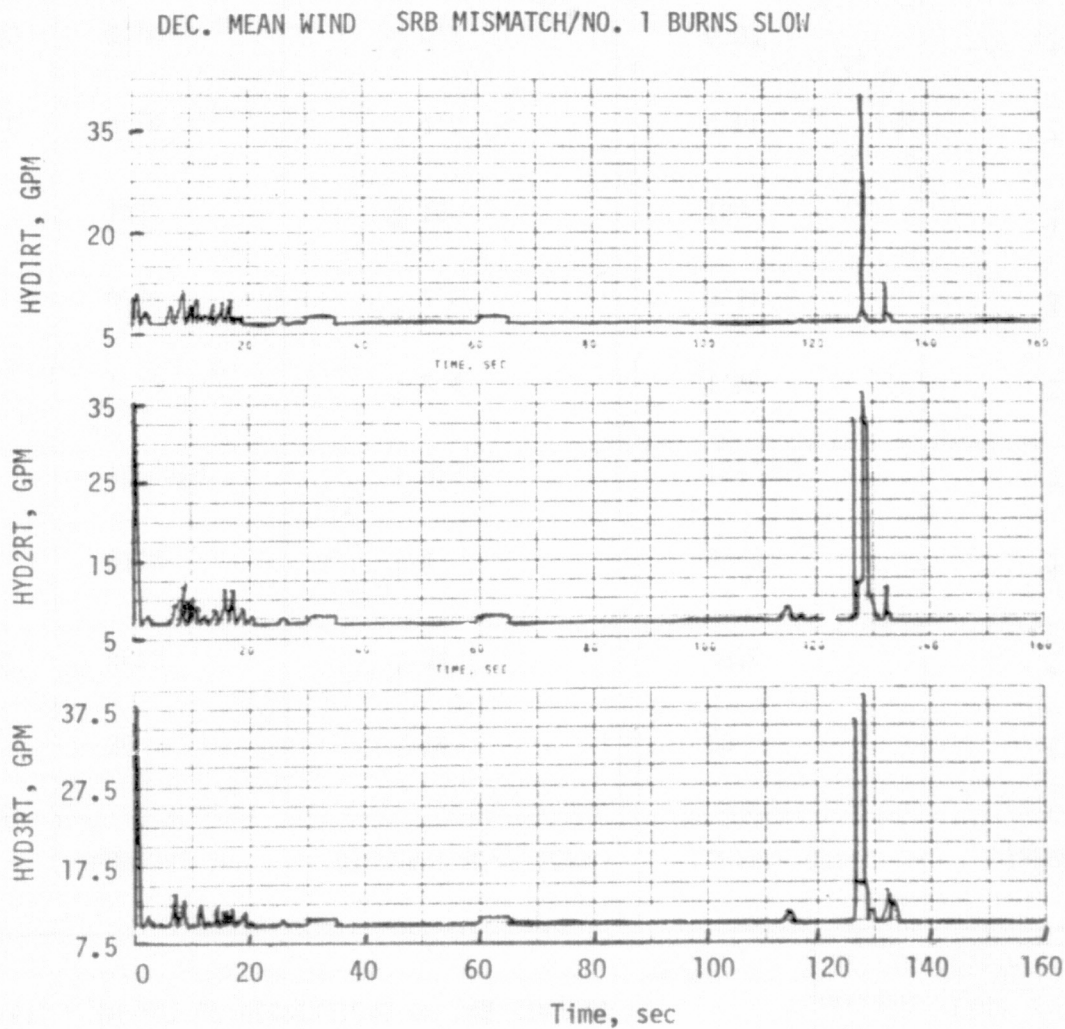


FIGURE 163.- IMPACT OF SRB MISMATCH ON HYDRAULIC FLOW REQUIREMENTS/OFT-1

ENGINEERING ANALYSIS DIVISION/EX

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APRIL MEAN WIND SRB MISMATCH/NO. 2 BURNS SLOW

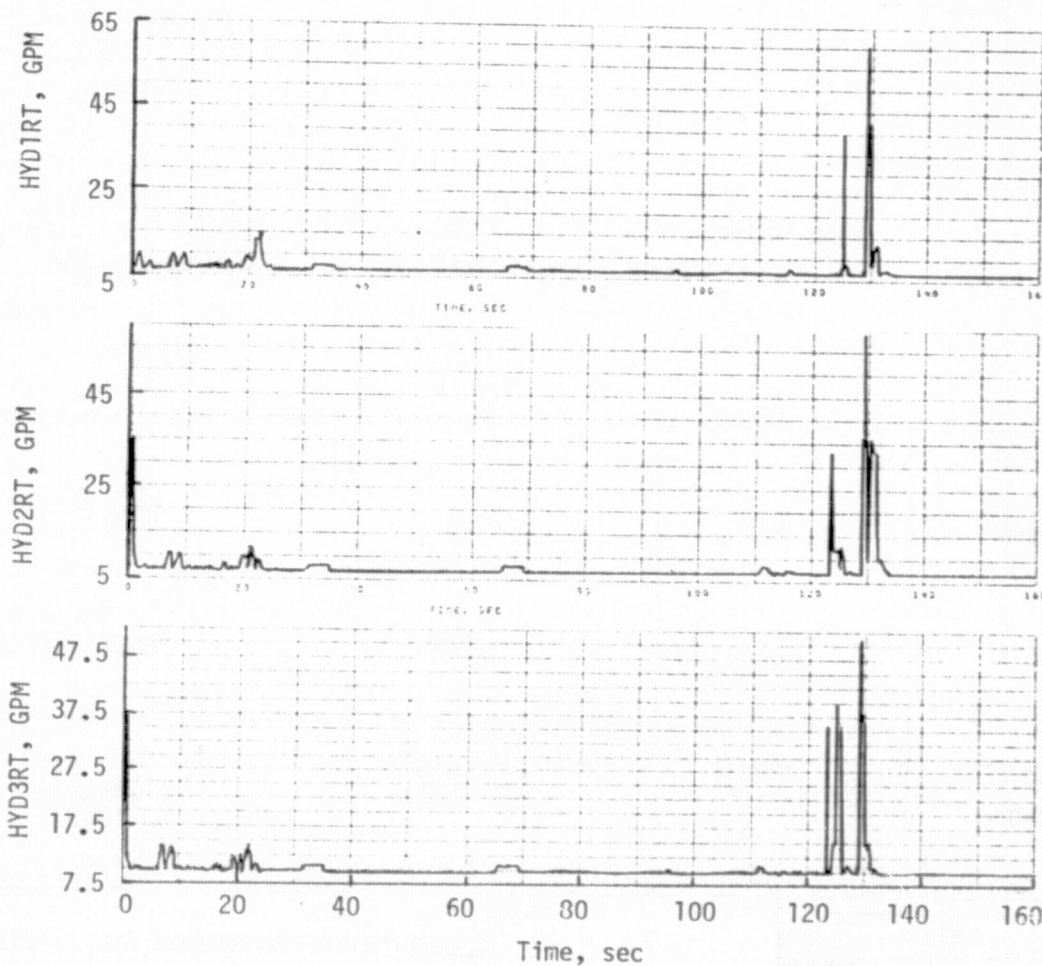


FIGURE 164. - SSV PERFORMANCE REQUIREMENTS

ENGINEERING ANALYSIS DIVISION/EX

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MISSION	FLIGHT PERFORMANCE RESERVE, FPR, LBS.	WORST CASE WIND EFFECT, LBS.	RSS DISPERSIONS EFFECT, LBS	PROPELLANT REQUIRED, LBS
3A	5200	-1400	+ - 3800	5200
OFT-1	5200	-3600	+ - 4960	8560

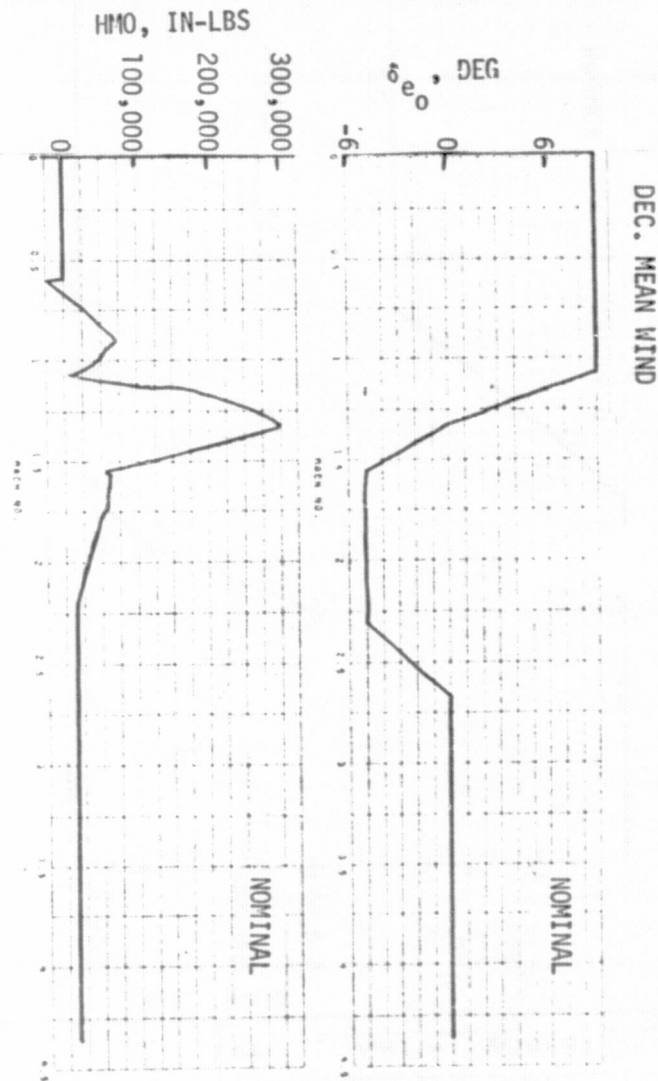
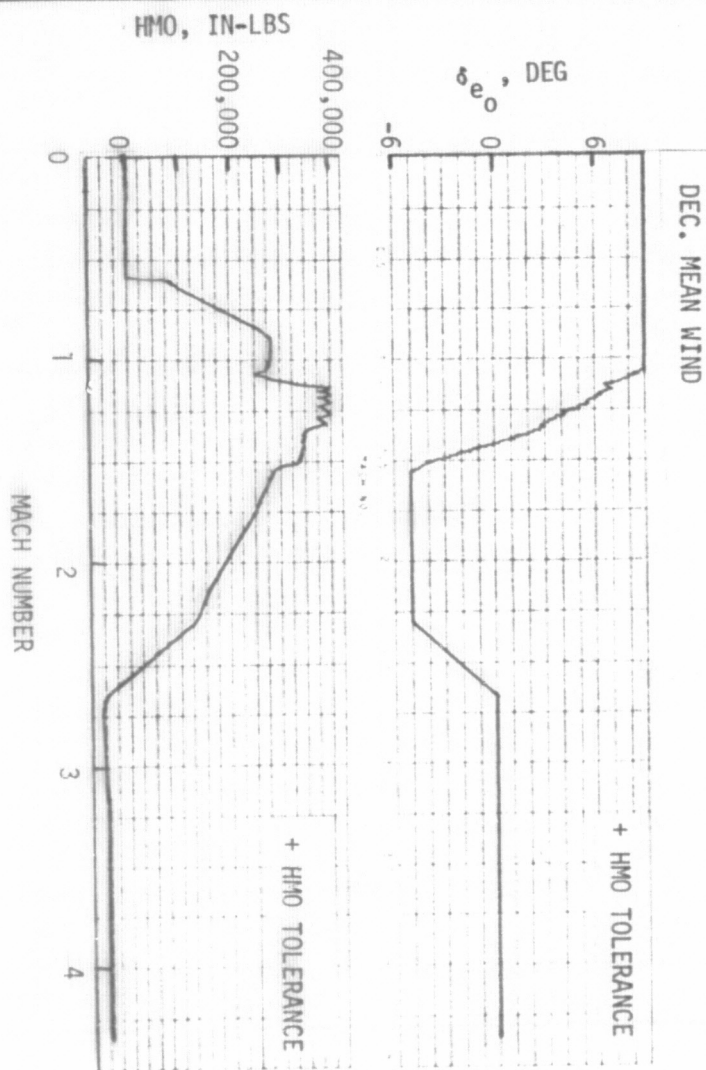
NOTE: PERFORMANCE EFFECTS (WINDS AND DISPERSIONS) REPRESENT
A CHANGE IN THE SSV INJECTED WEIGHT AT NOMINAL MECO

FIGURE 165.- IMPACT OF OUTBOARD ELEVON HINGE MOMENT TOLERANCE/3A

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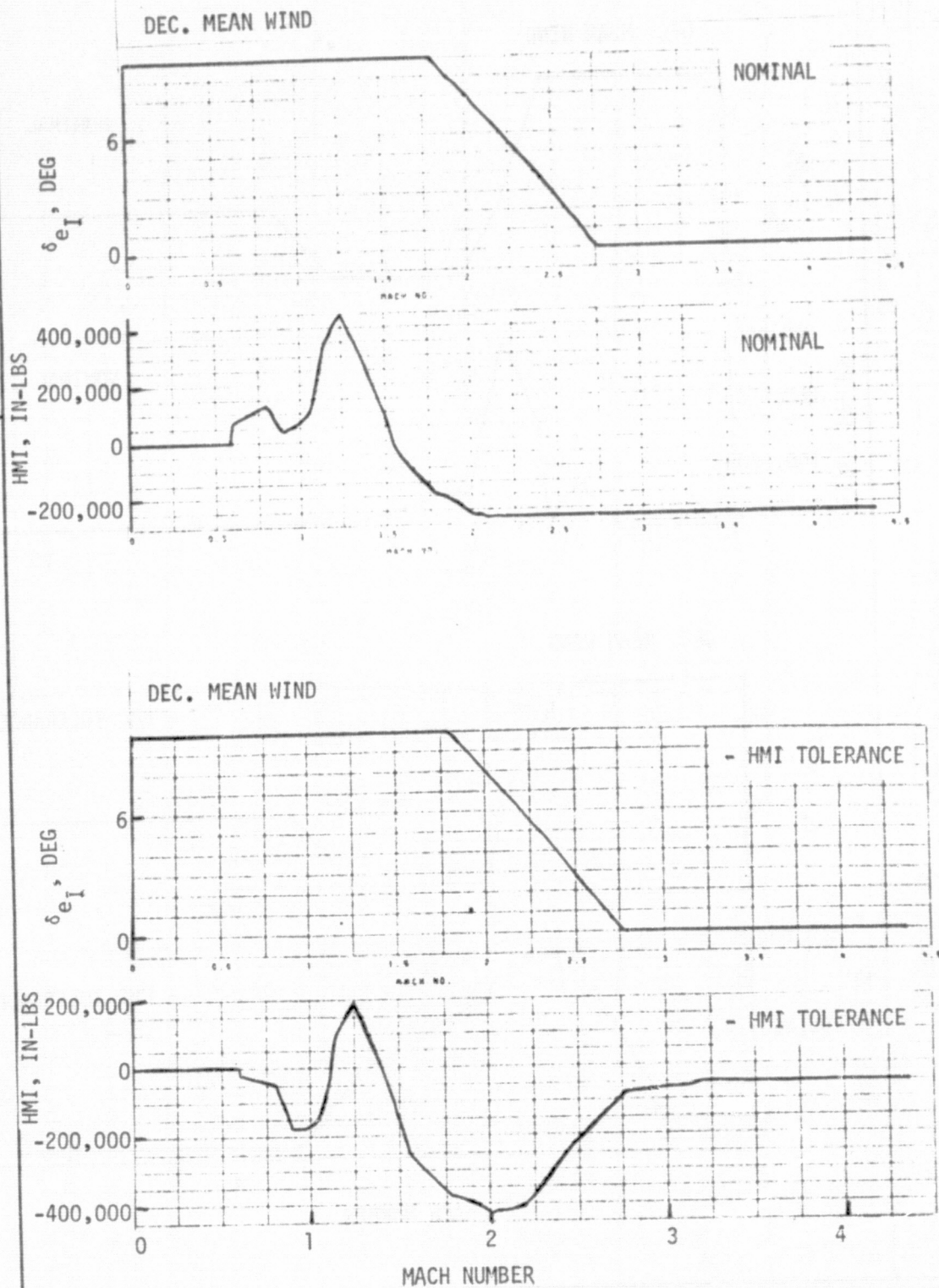


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FIGURE 166.- IMPACT OF INBOARD ELEVON HINGE MOMENT TOLERANCES/3A



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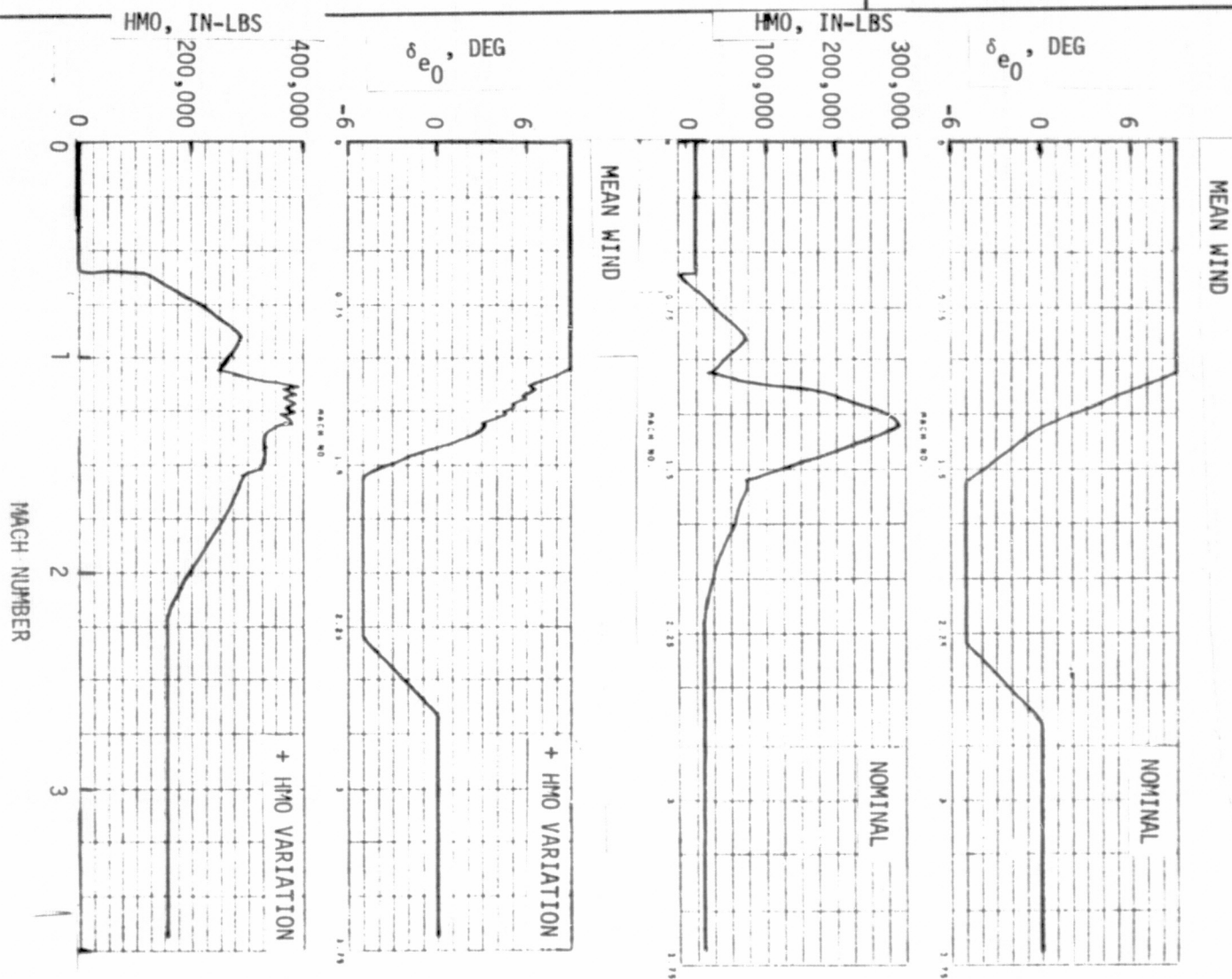
JSC FORM 1138 (MAR 73)

FIGURE 167.- IMPACT OF OUTBOARD ELEVEN HINGE MOMENT VARIATION/OFT-1

ENGINEERING ANALYSIS DIVISION/EX

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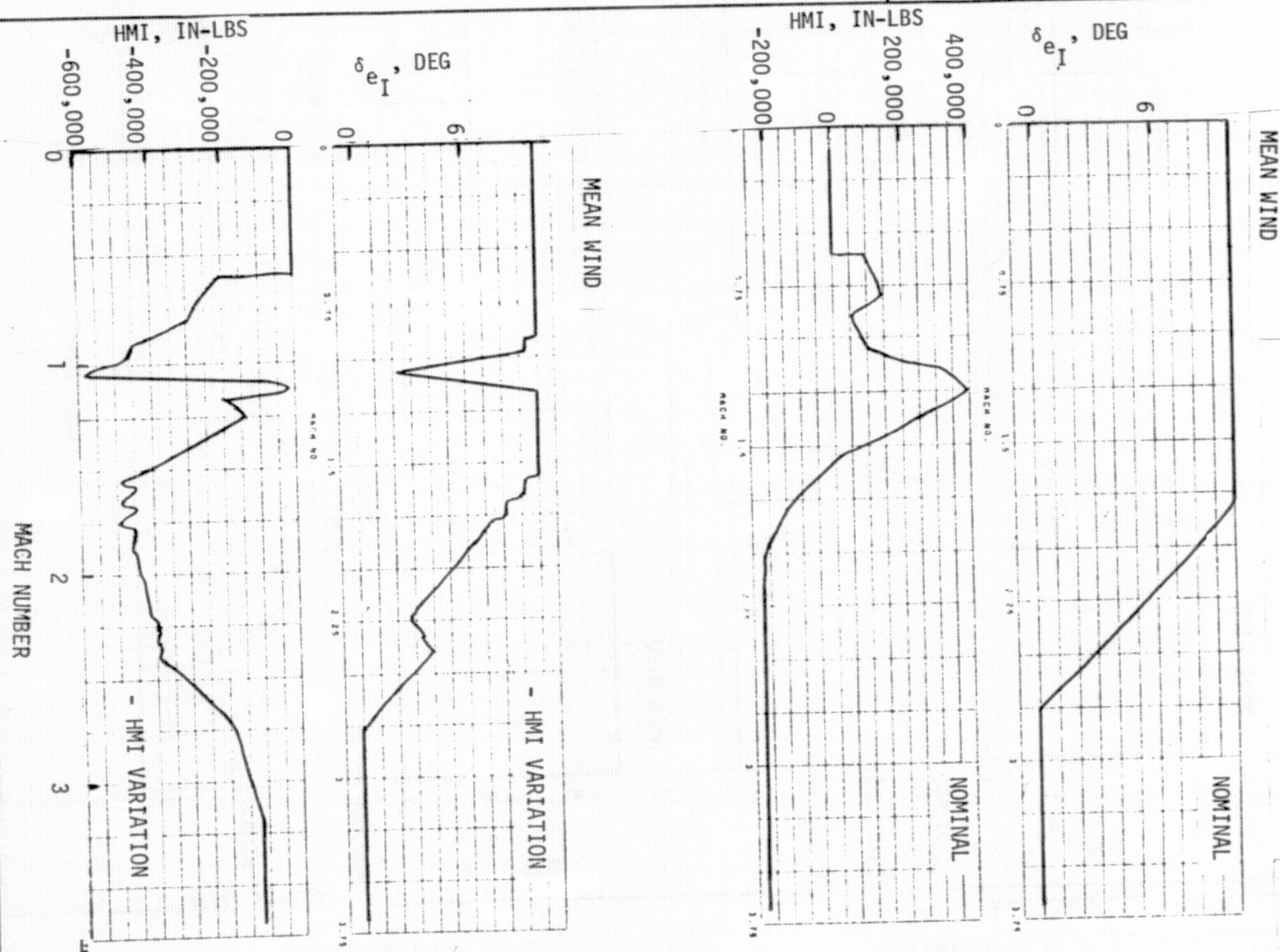
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FIGURE 168.- IMPACT OF INBOARD ELEVEN HINGE MOMENT VARIATIONS/OFT-1



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FIGURE 169.- IMPACT OF ELEMENT UNCERTAINTIES/WING ROOT BENDING

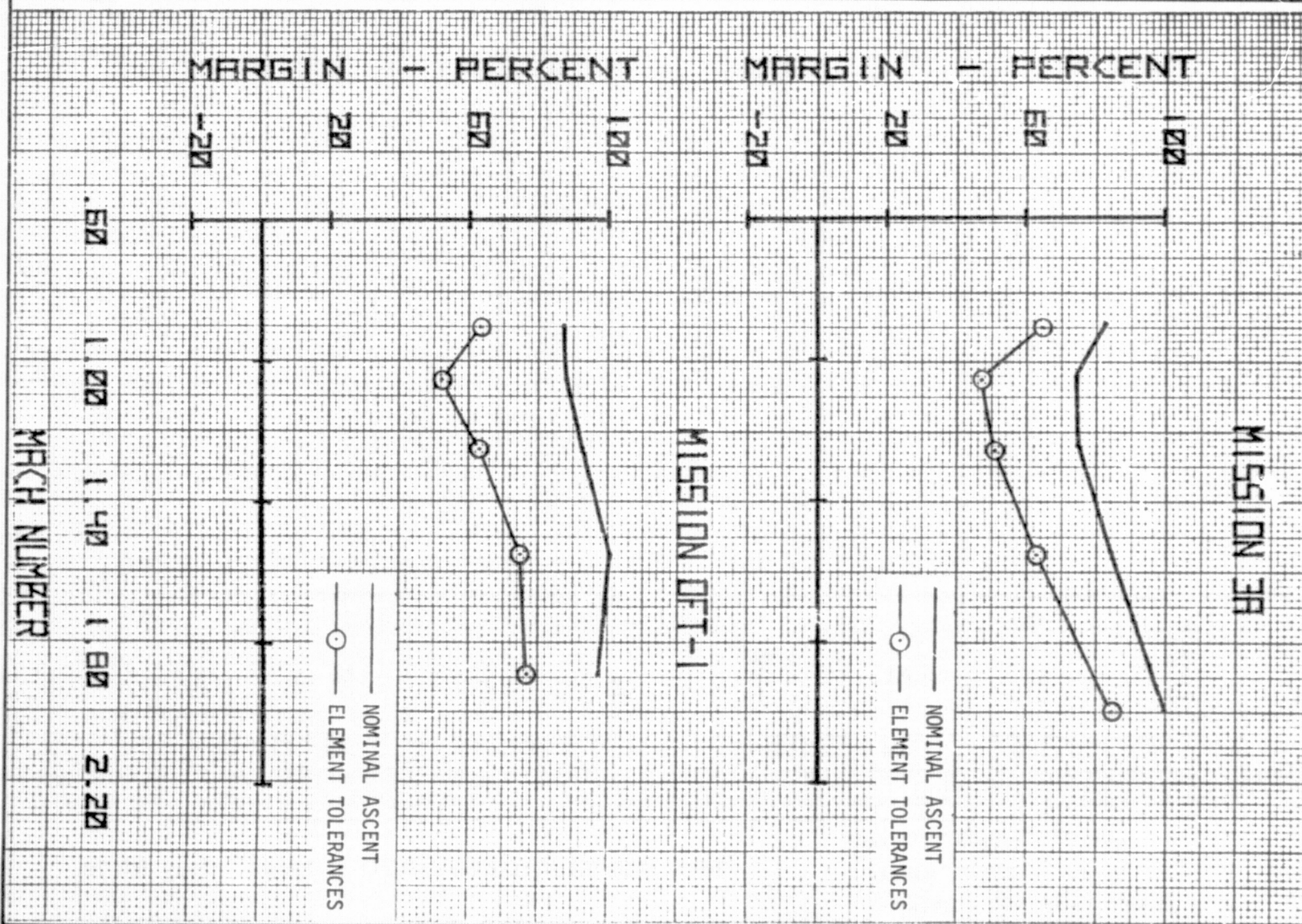
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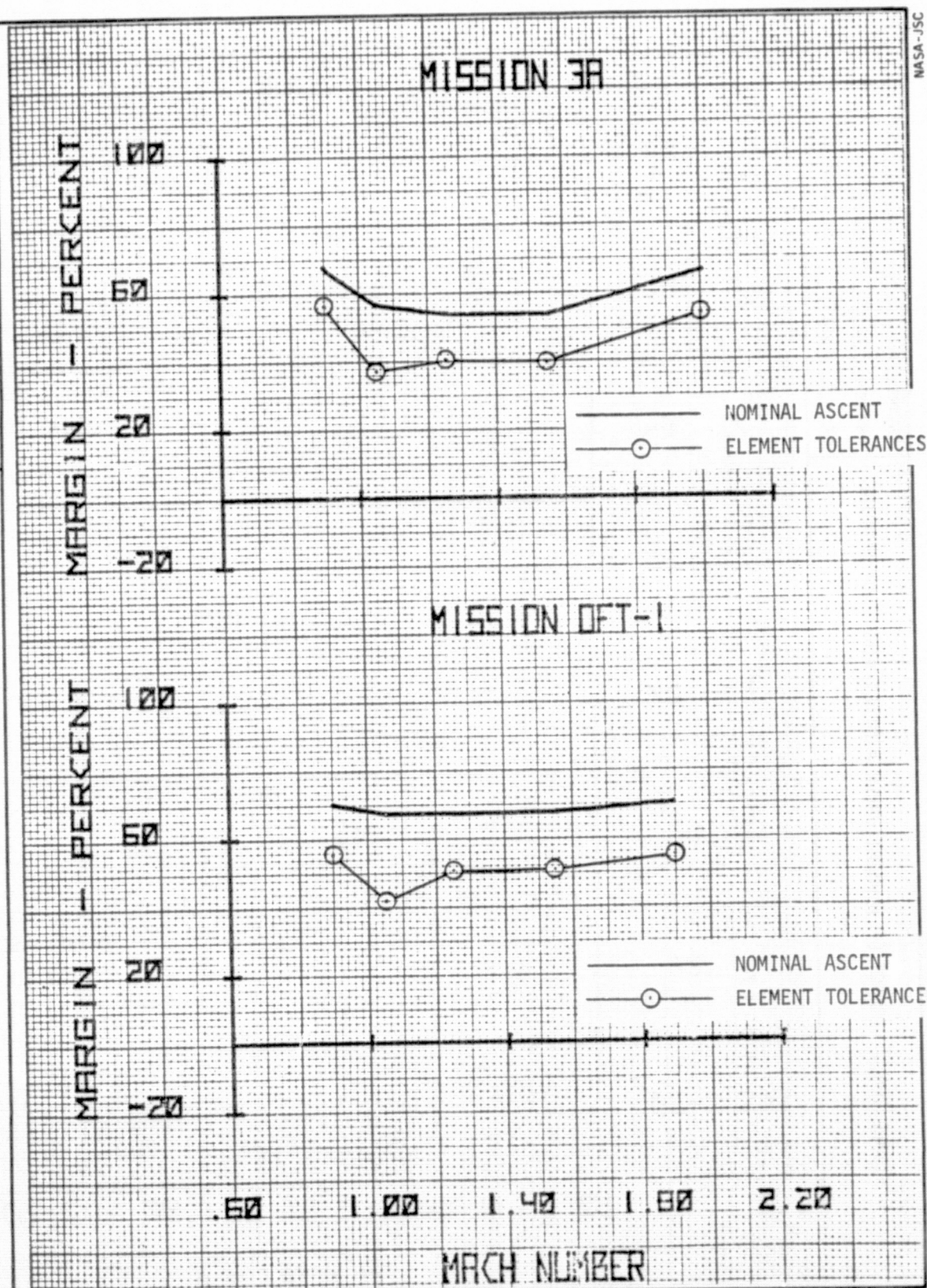
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FIGURE 170.- IMPACT OF ELEMENT UNCERTAINTIES/WING SHEAR



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FIGURE 171.- IMPACT OF ELEMENT UNCERTAINTIES/OUTBOARD
ELEVON HINGE MOMENT

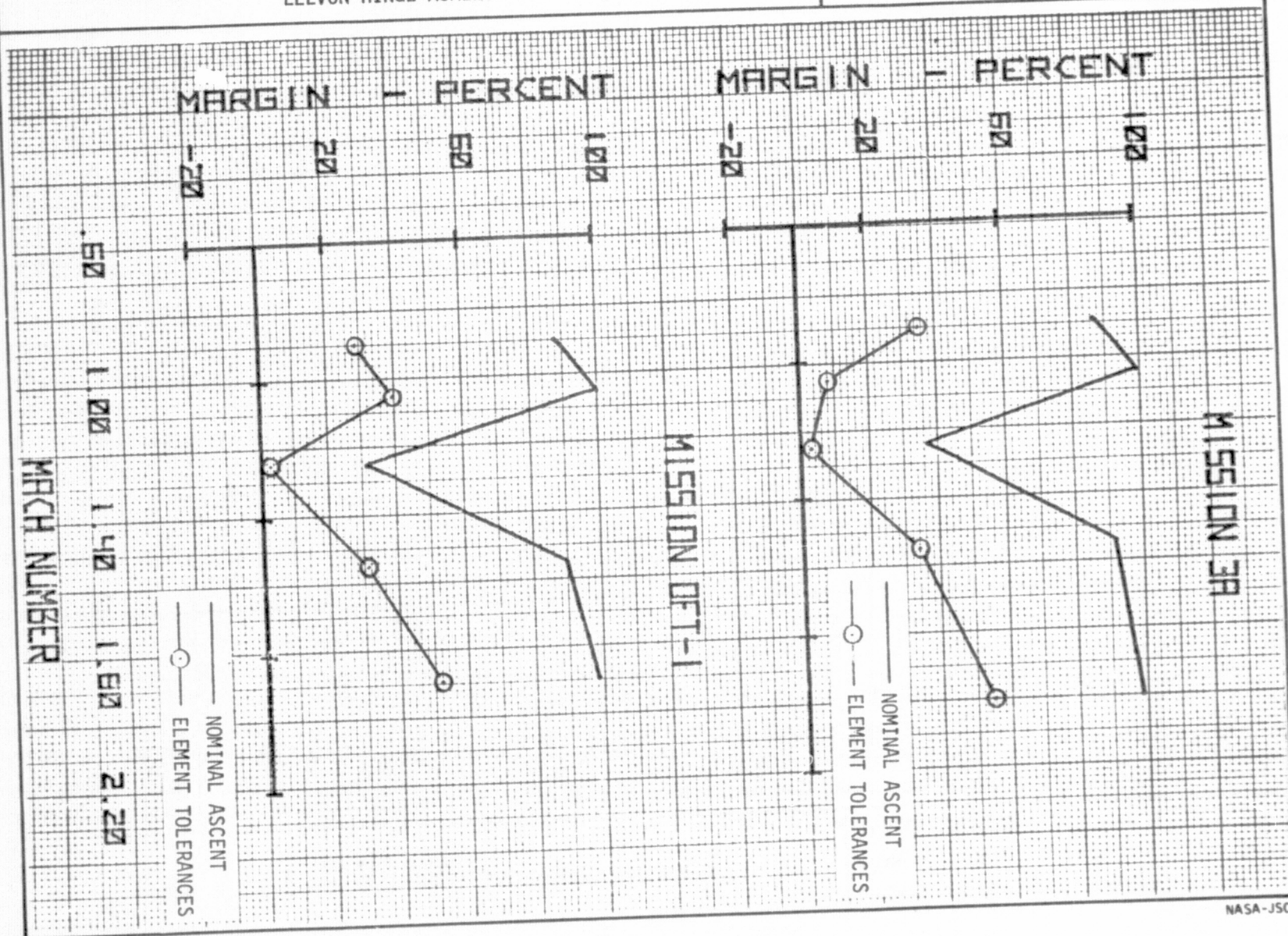
ENGINEERING ANALYSIS DIVISION/EX

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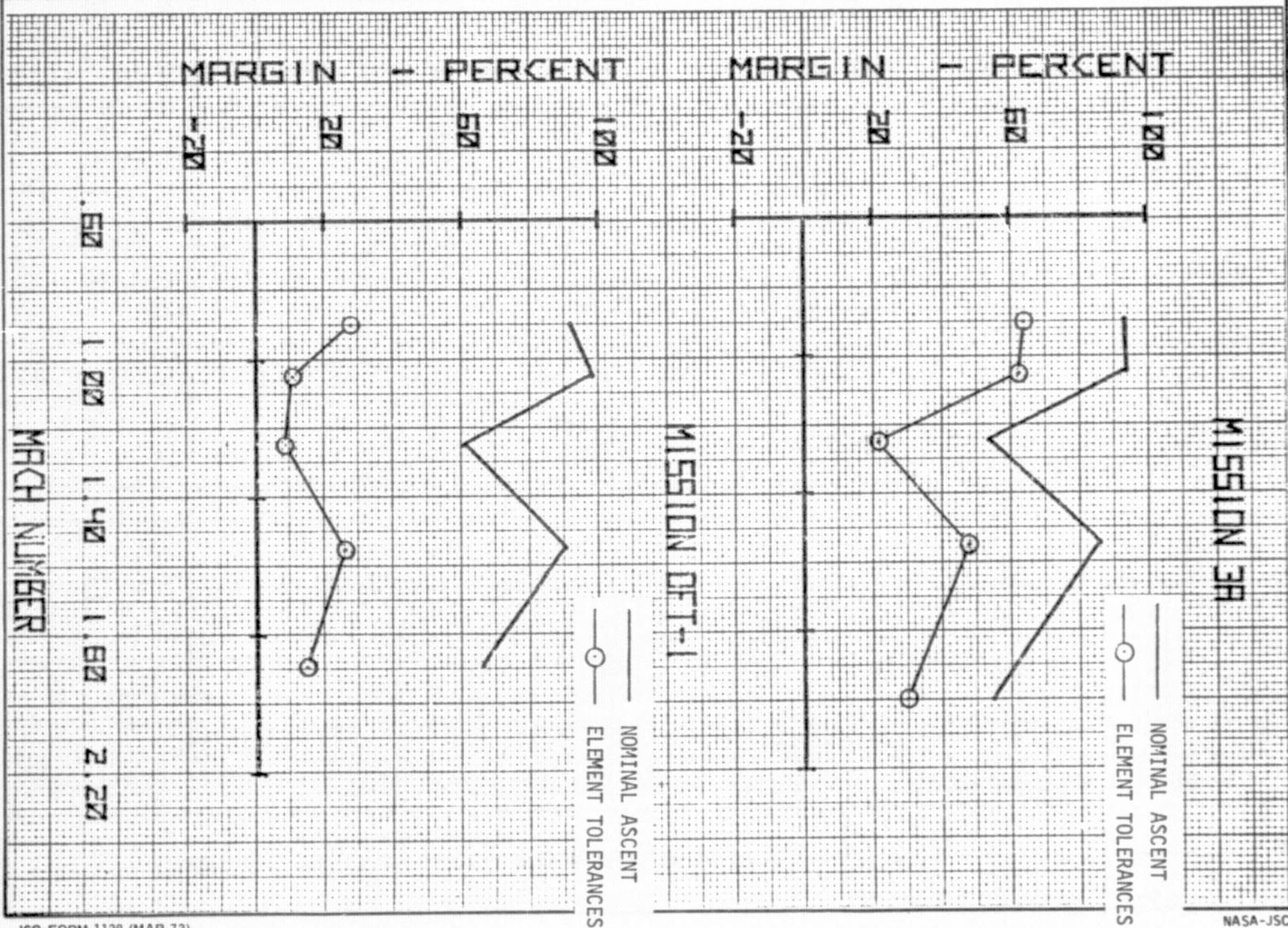
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FIGURE 172.- IMPACT OF ELEMENT UNCERTAINTIES/INBOARD
ELEVON HINGE MOMENT

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FIGURE 173.- IMPACT OF ELEMENT UNCERTAINTIES/FT01

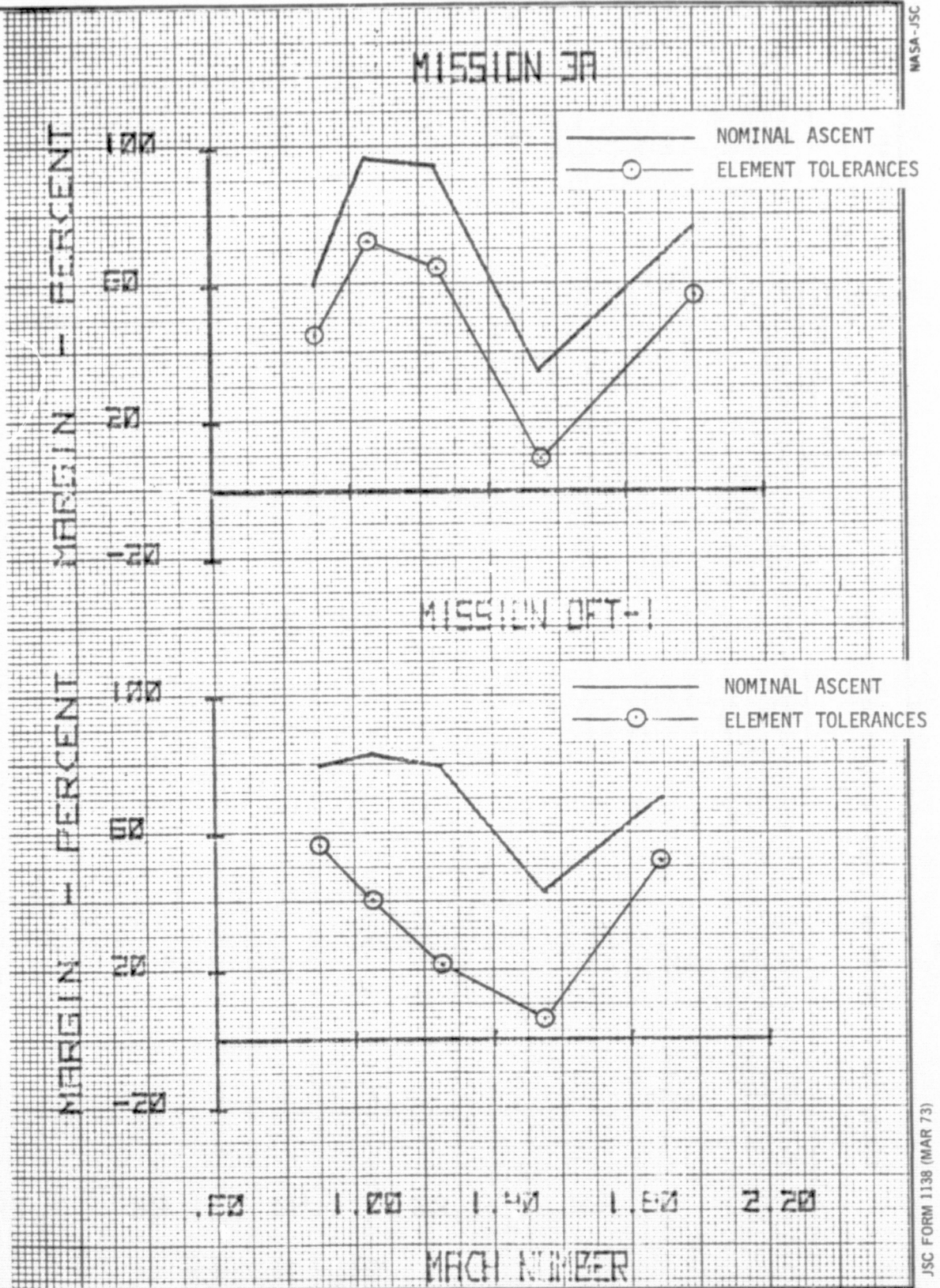


FIGURE 174.- IMPACT OF ELEMENT UNCERTAINTIES/FT02

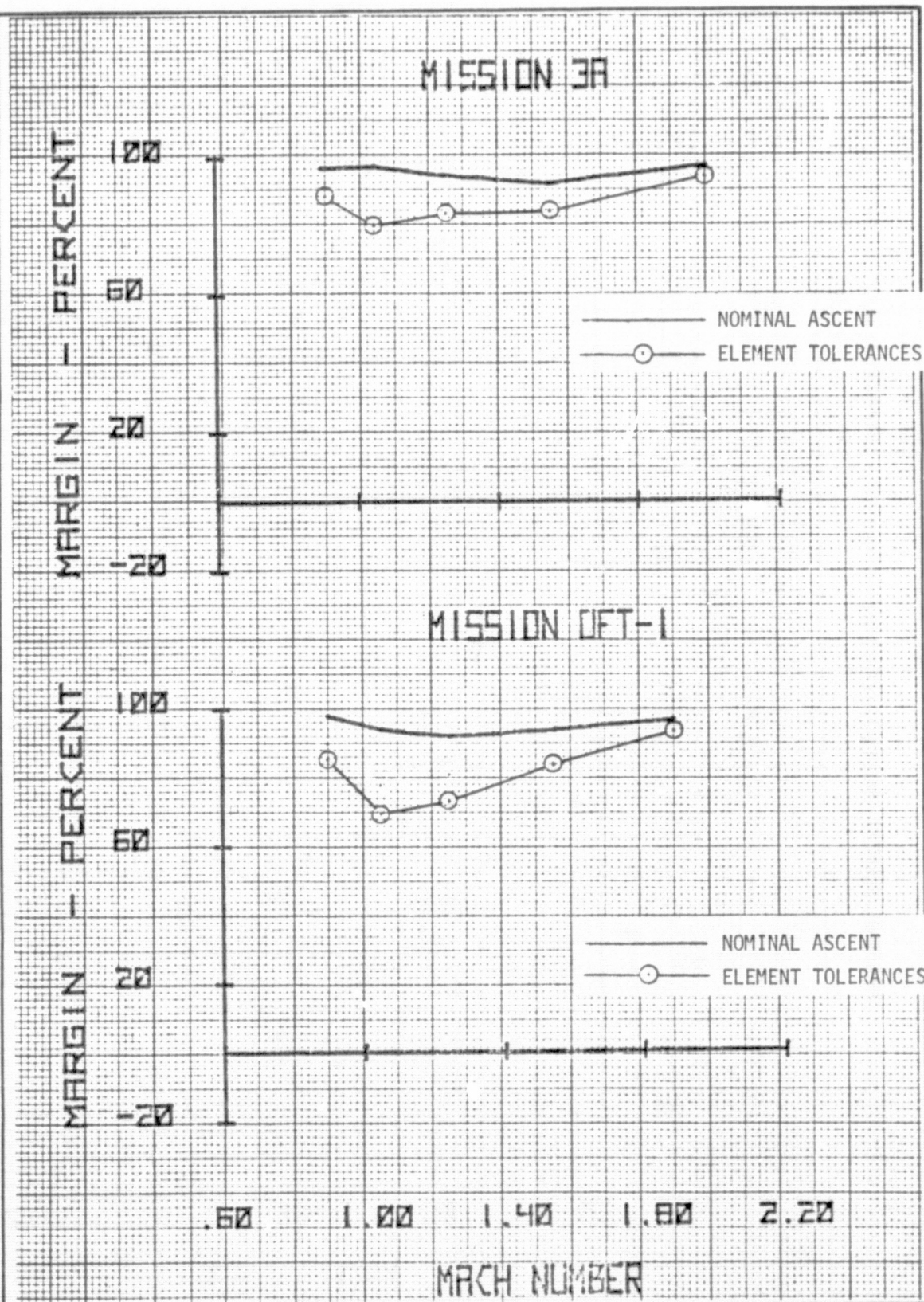


FIGURE 175.- IMPACT OF ELEMENT UNCERTAINTIES/FT03

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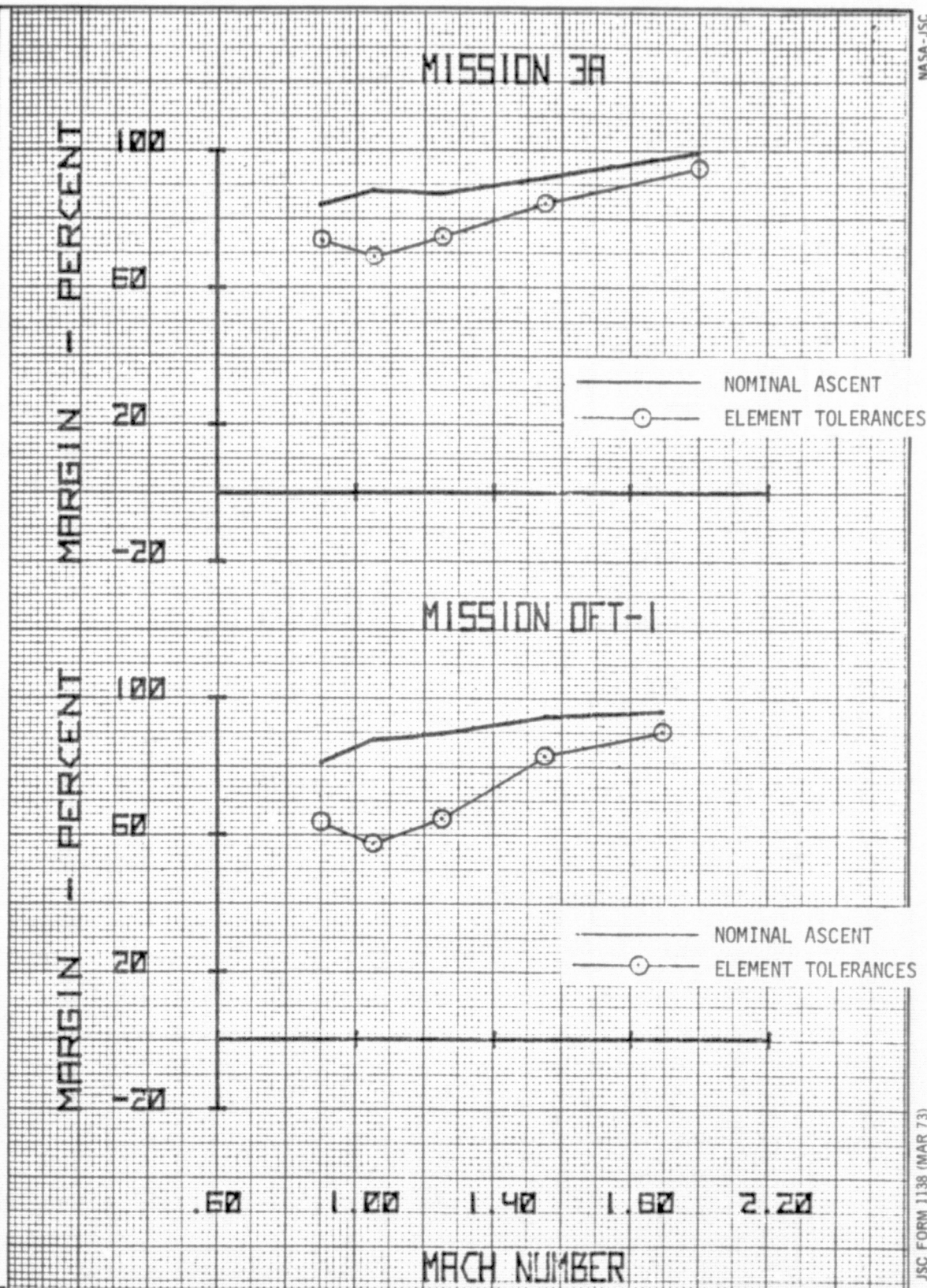
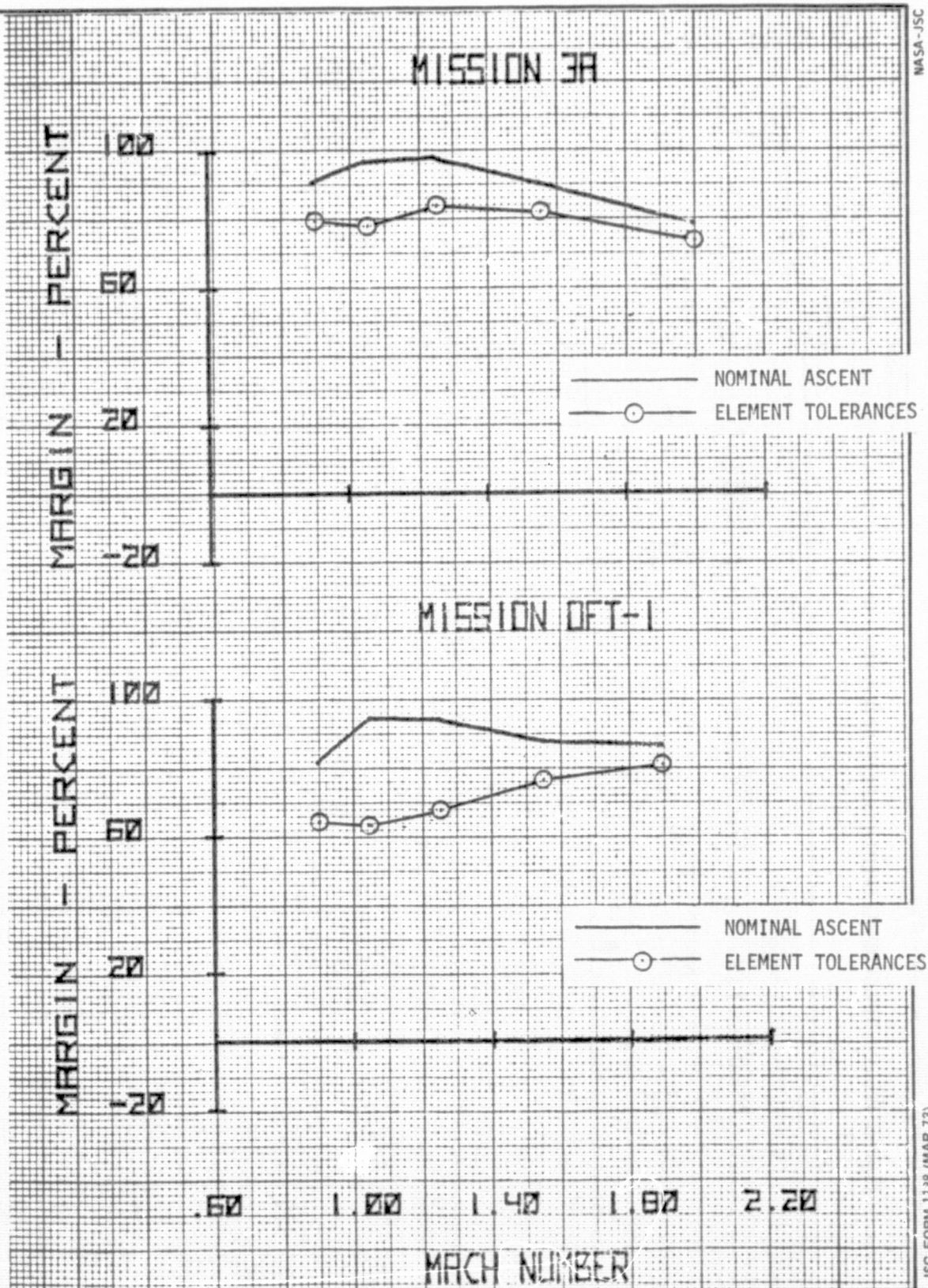


FIGURE 176.- IMPACT OF ELEMENT UNCERTAINTIES/FT04

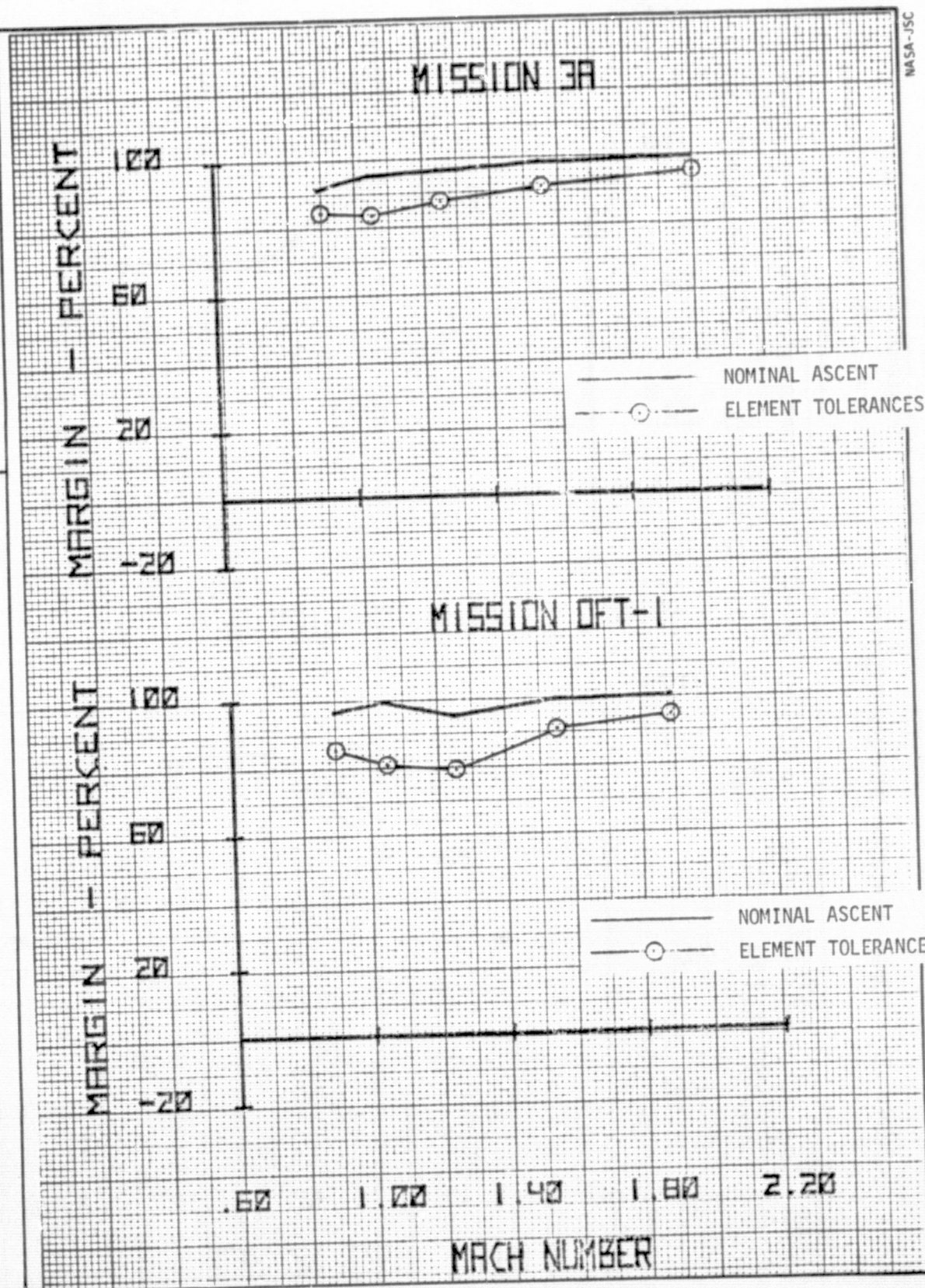


ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

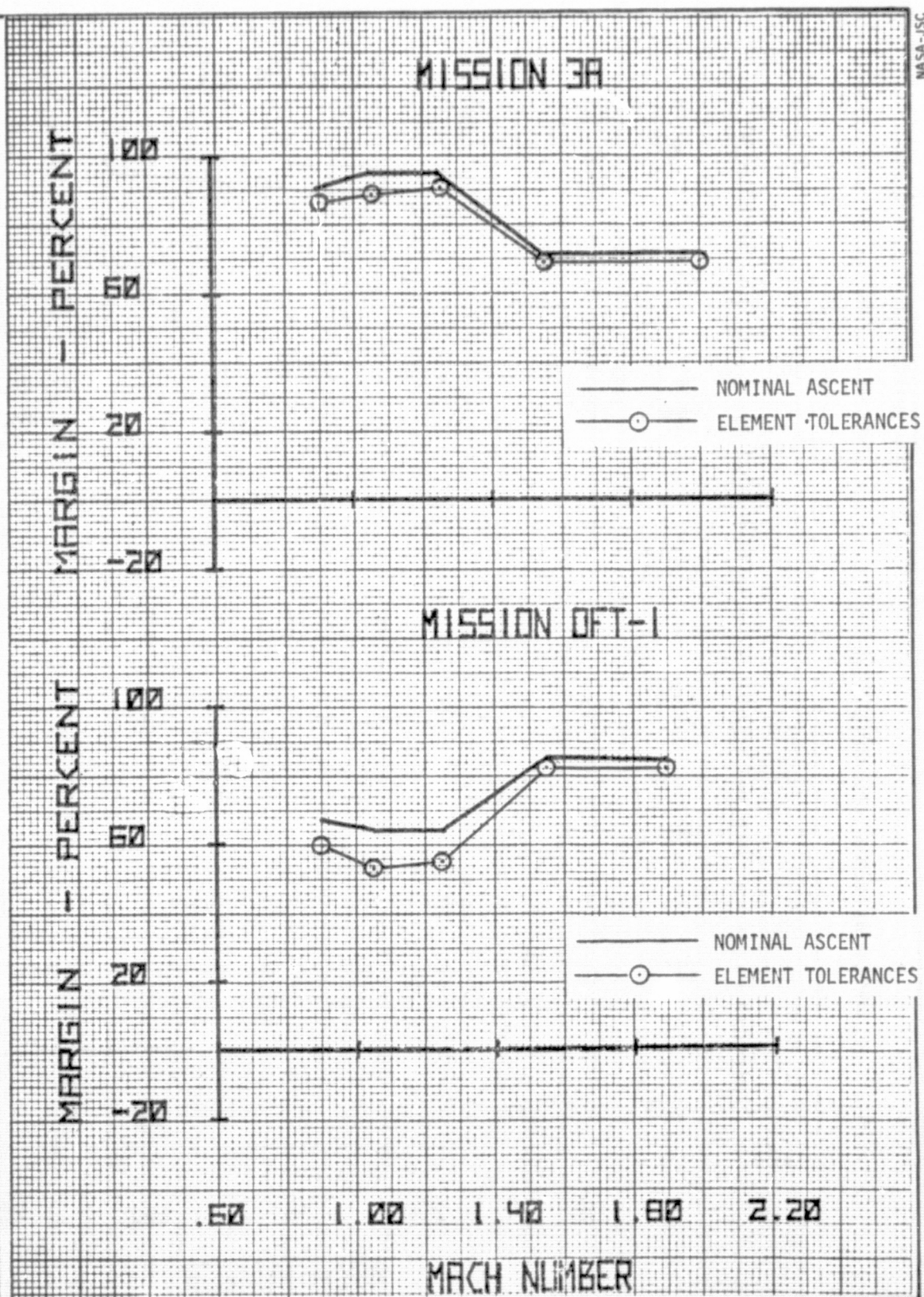
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FIGURE 177.- IMPACT OF ELEMENT UNCERTAINTIES/FT06



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FIGURE 173.- IMPACT OF ELEMENT UNCERTAINTIES/FT07

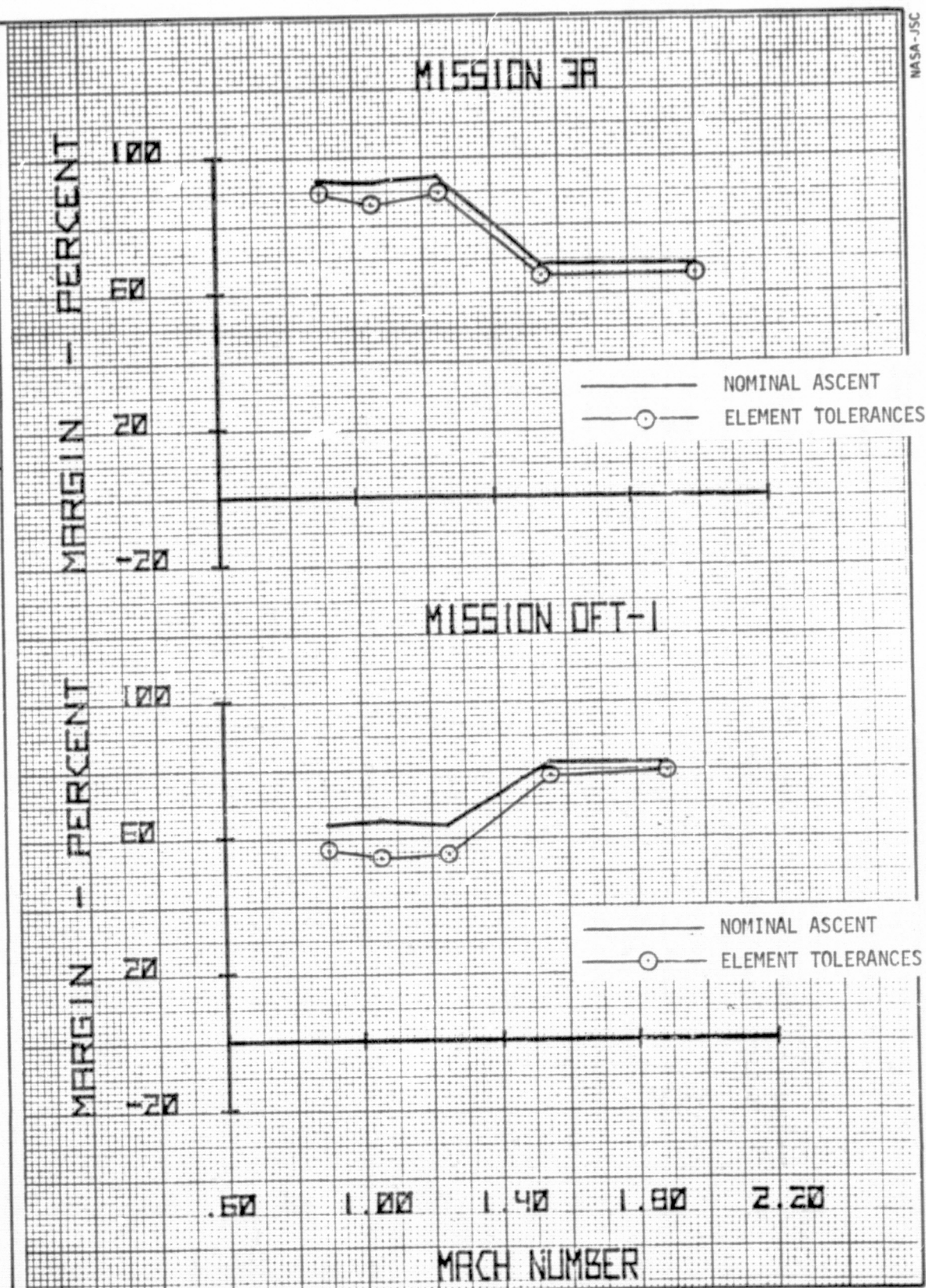


ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

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FIGURE 179.- IMPACT OF ELEMENT UNCERTAINTIES/FT08



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FIGURE 180.- IMPACT OF ELEMENT UNCERTAINTIES/FTB 1,2

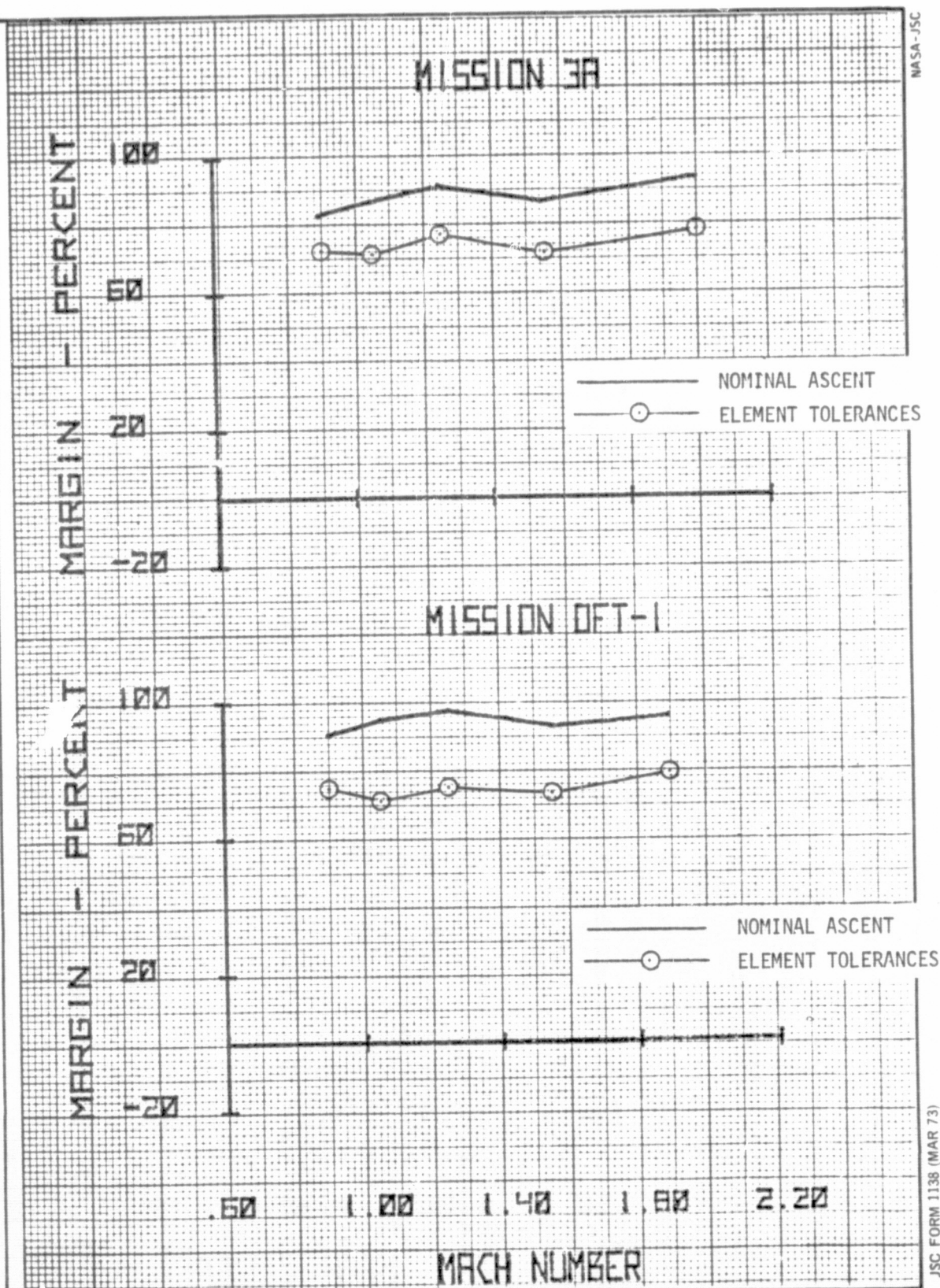
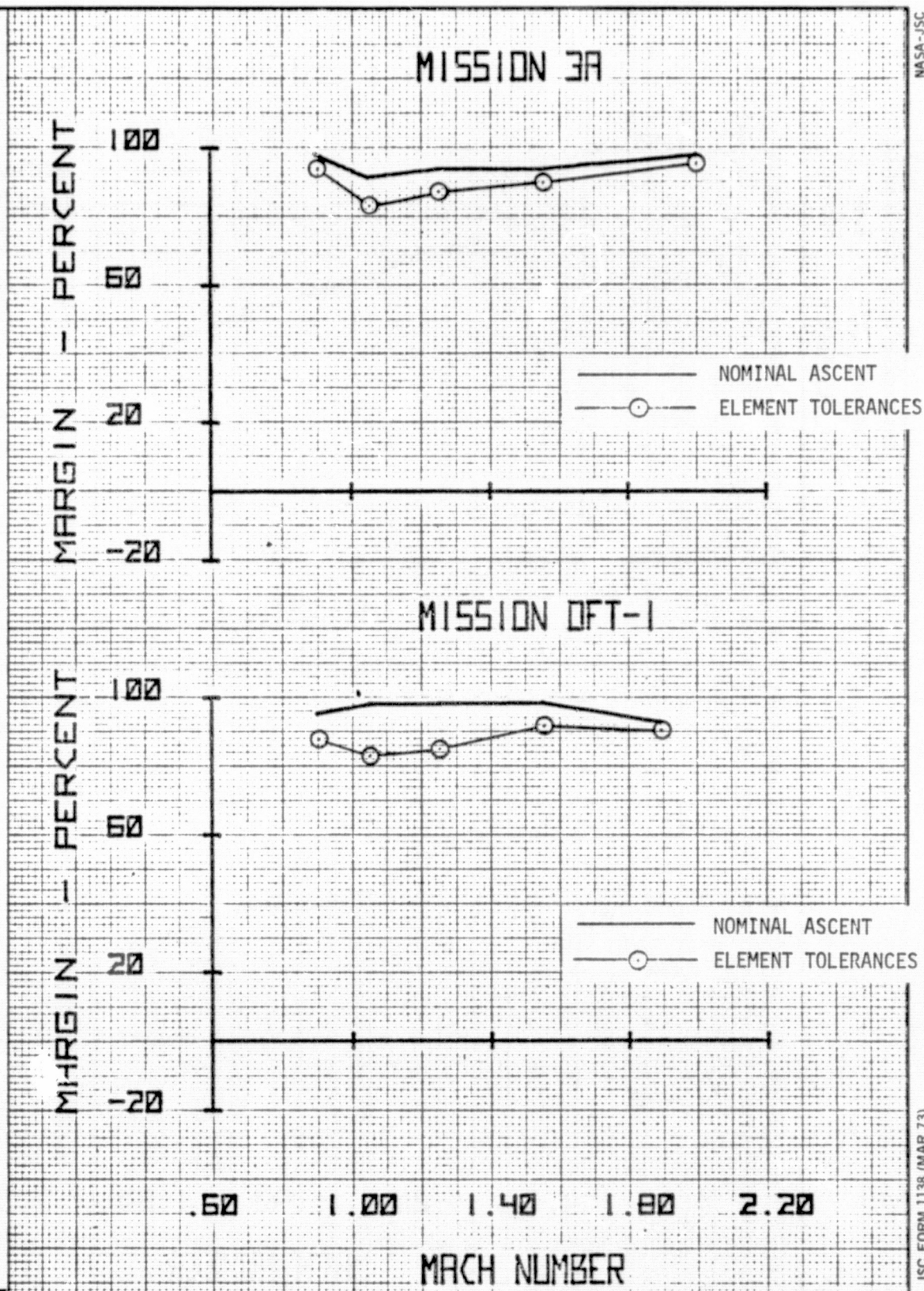


FIGURE 181.- IMPACT OF ELEMENT UNCERTAINTIES/FTB 3,4

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

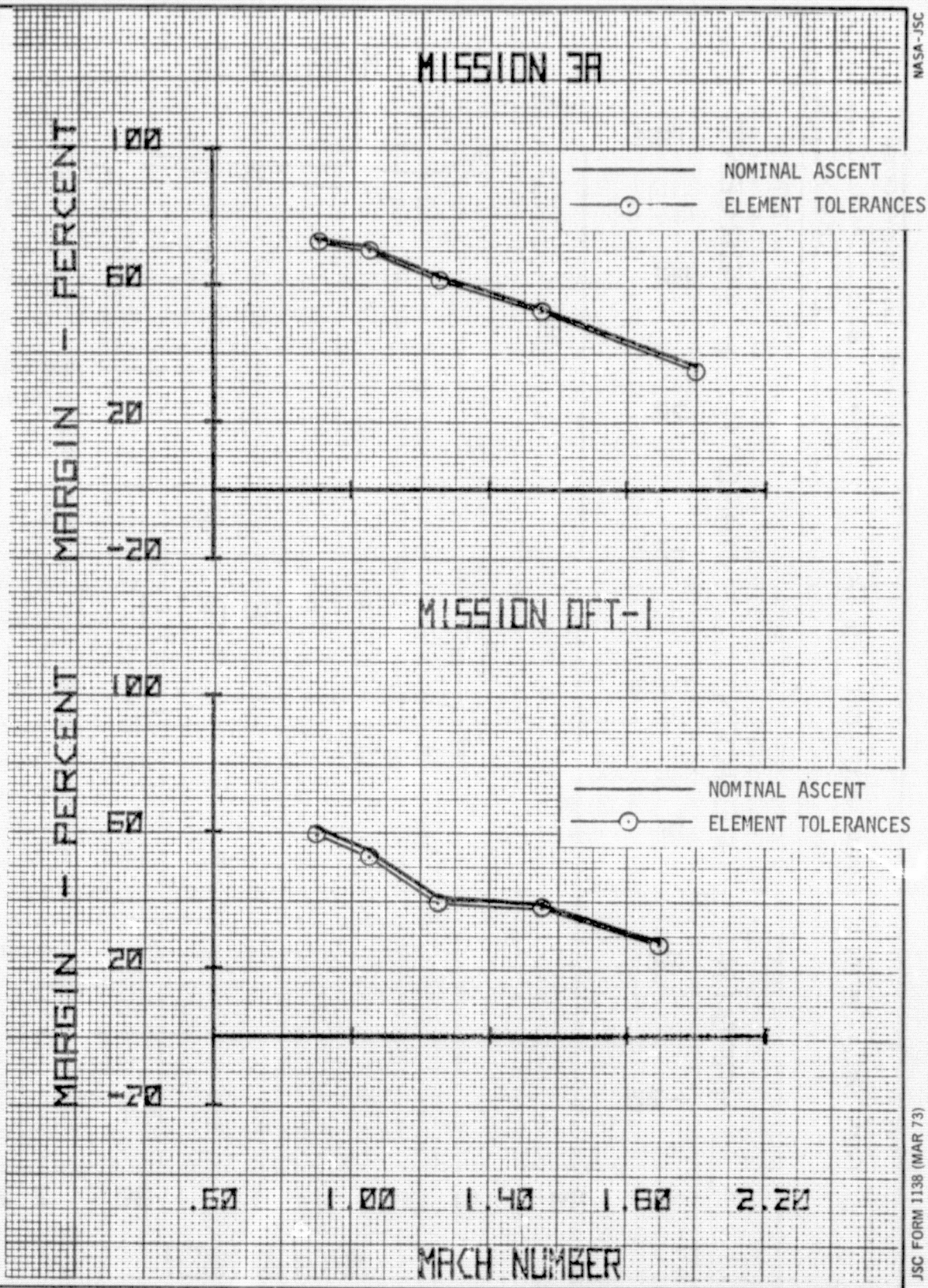


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BRANCH EX42 DATE

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FIGURE 182.- IMPACT OF ELEMENT UNCERTAINTIES/FTB 5,6



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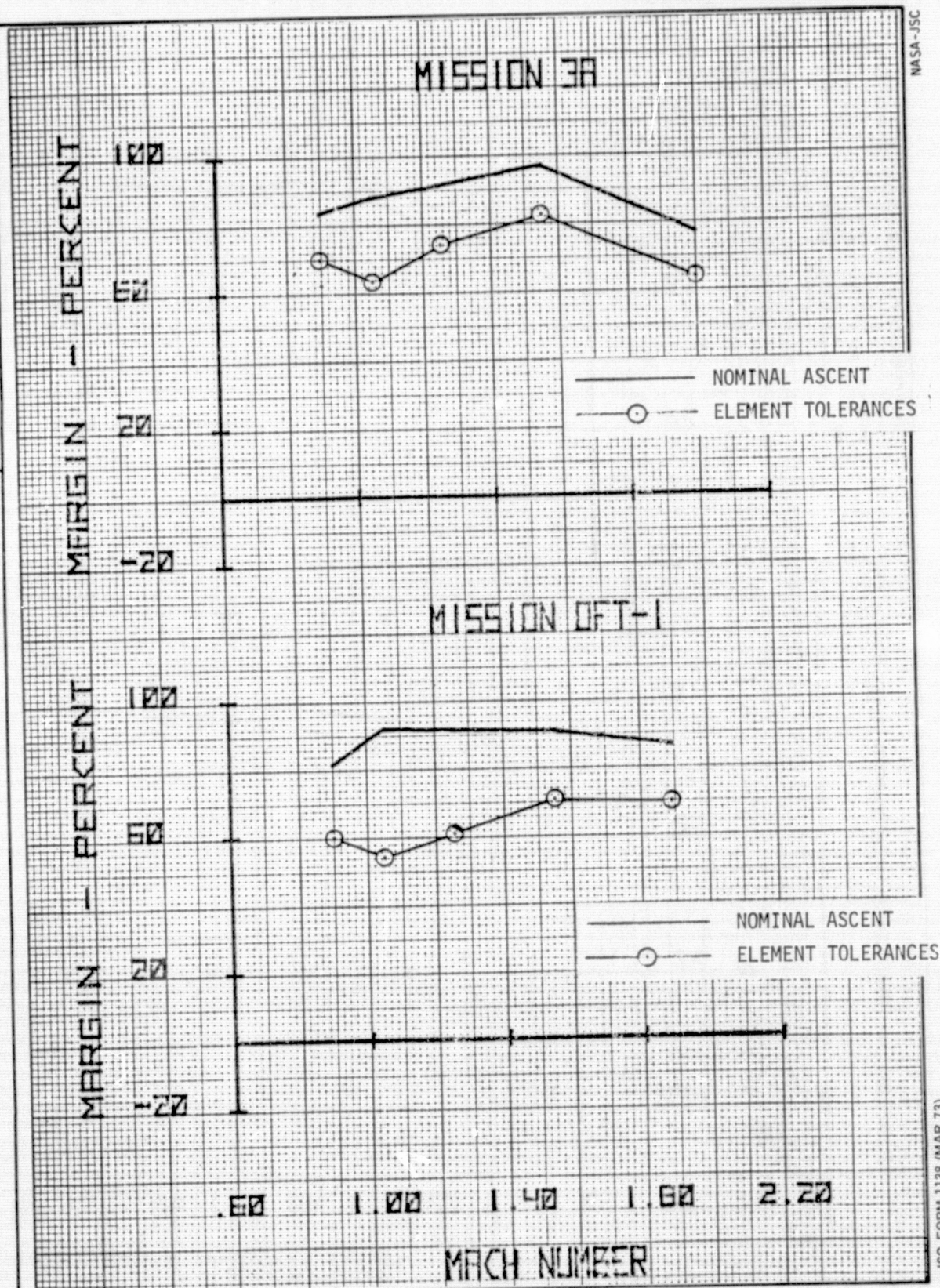
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ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

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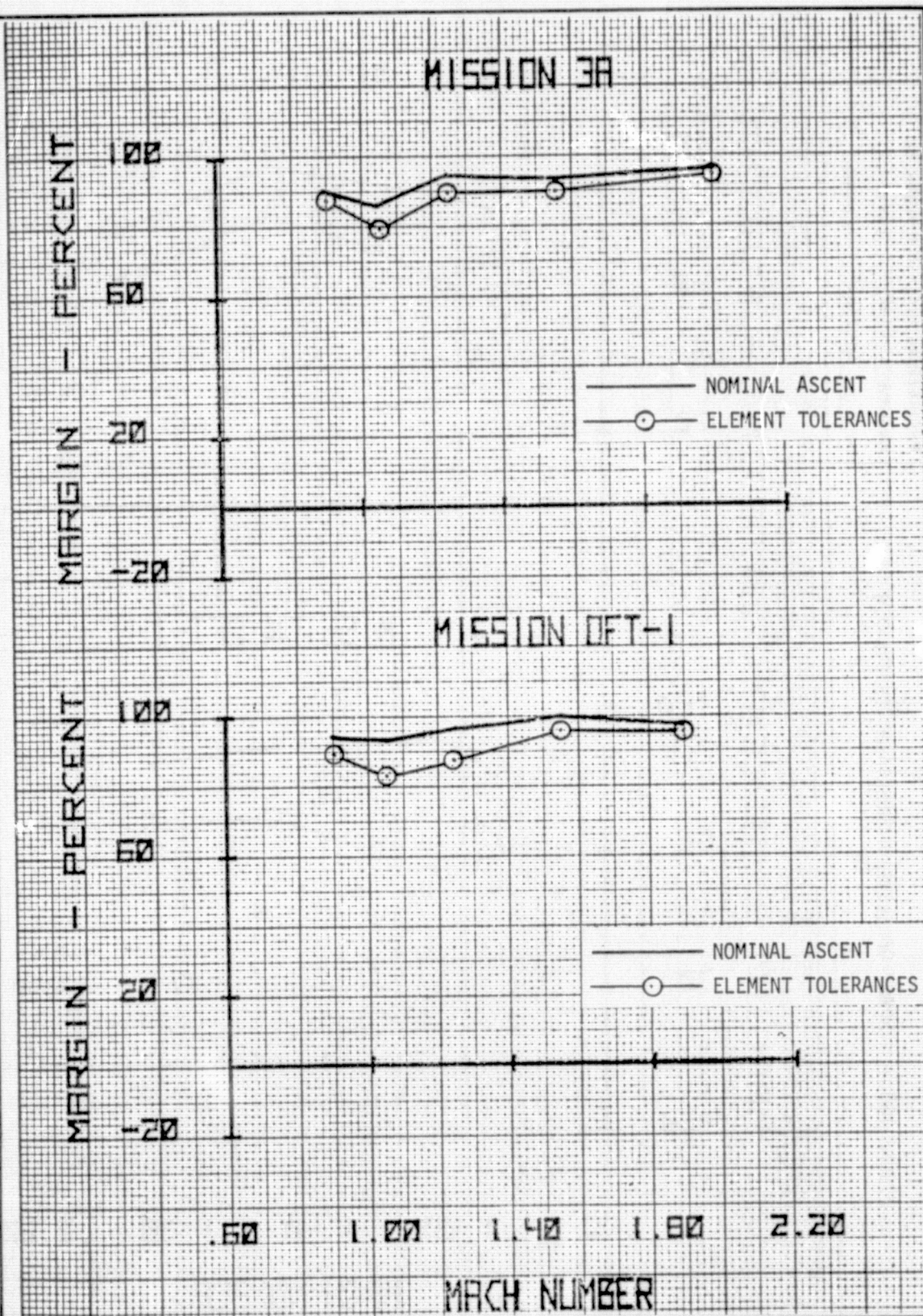
FIGURE 183.- IMPACT OF ELEMENT UNCERTAINTIES/FTB 7,8



NASA-JSC

JSC FORM 1138 (MAR 73)

FIGURE 184.- IMPACT OF ELEMENT UNCERTAINTIES/FTB 9,10



NASA-JSC

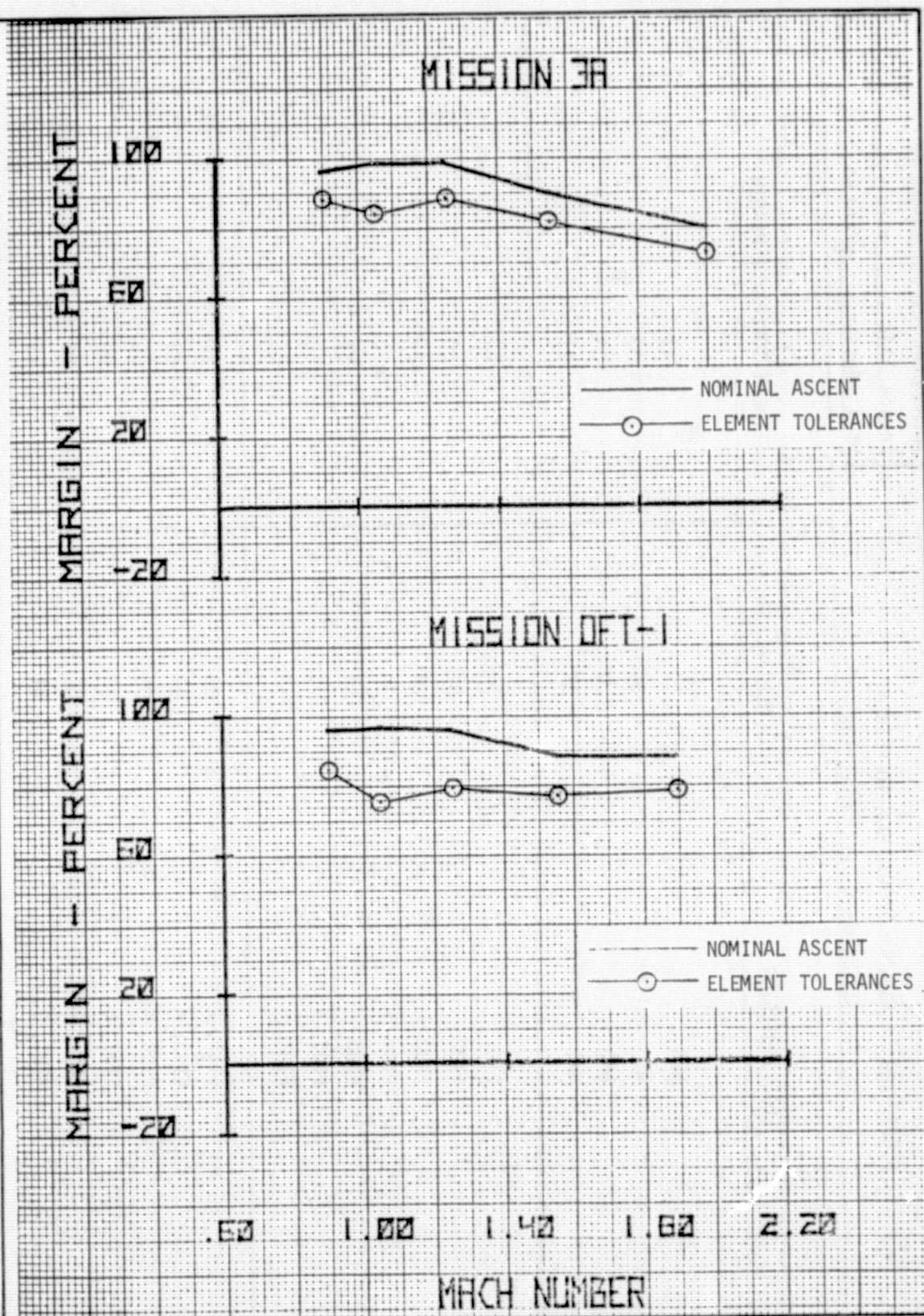
JSC FORM 1138 (MAR 73)

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

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FIGURE 185.- IMPACT OF ELEMENT UNCERTAINTIES/MTB 1,2



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FIGURE 186. - MINIMUM MARGIN DUE TO ELEMENT
AERODYNAMIC TOLERANCES (3A)

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE _____

BY L. Austin

PLOT NO. _____

LOAD INDICATOR	NOMINAL 3A	ELEMENT TOLERANCE MARGIN
WRB	74	47
WS	54	37
HMO	37	3*
HMI	54	Li
FT01	35	9
FT02	92	80
FT03	84	69
FT04	78	78
FT06	91	84
FT07	71	69
FT08	68	65
FTB1, 2	83	71
FTB3, 4	91	83
FTB5, 6	36	35
FTB7, 8	77	63
FTB9, 10	86	80
MTB1, 2	81	73

Note: $0.90 \leq \text{Mach No.} \leq 2.0$

*Elevon Load Relief at 400K in-lbs.

FIGURE 187. - MINIMUM MARGIN DUE TO ELEMENT
AERODYNAMIC VARIATIONS (OFT-1)

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE _____

BY L. Austin

PLOT NO. _____

LOAD INDICATOR	NOMINAL OFT	ELEMENT VARIATION MARGIN
WRB	87	52
WS	67	32
HMO	31	3*
HMI	61	9**
FT01	43	5
FT02	92	70
FT03	81	58
FT04	81	63
FT06	94	79
FT07	64	53
FT08	64	54
FTB1, 2	90	71
FTB3, 4	93	83
FTB5, 6	28	27
FTB7, 8	81	54
FTB9, 10	93	83
MTB1, 2	88	75

Note: $0.90 < \text{Mach No.} < 2.0$

* Elevon Load Relief at 400K in-lbs.

** Elevon Load Relief at -500K in-lbs.

FIGURE 188.- MISSION 3A - MINIMUM INDICATOR MARGINS, %

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE _____

BY L. Austin PLOT NO. _____

STRUCTURAL LOAD INDICATOR	NOMINAL ASCENT	Δ MARGIN			MINIMUM MARGIN
		INFLIGHT WINDS	SSV SYSTEM DISPERSIONS	ELEMENT TOLERANCES	
WRB	74	47	21	27	15
WS	54	38	31	17	1
HMO	37	34*	2	34*	*
HMI	54	12	6	33	18
FT01	35	1	9	26	8
FT02	92	41	10	12	49
FT03	84	47	14	15	32
FT04	78	34	8	0	38
FT06	91	31	11	7	56
FT07	71	9	16	2	53
FT08	68	13	15	3	48
FTB 1,2	83	1	8	12	70
FTB 3,4	91	12	14	8	75
FTB 5,6	36	2	3	1	32
FTB 7,8	77	39	18	14	28
FTB 9,10	86	13	6	6	70
MTB 1,2	81	23	10	8	54

NOTE: $0.90 \leq M \leq 2.0$

*ELEVON LOAD RELIEF AT 400K IN-LBS

FIGURE 189.- OFT-1 - MINIMUM INDICATOR MARGINS, %

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE _____

BY L. Austin PLOT NO. _____

STRUCTURAL LOAD INDICATOR	NOMINAL ASCENT	Δ MARGIN			MINIMUM MARGIN
		INFLIGHT WINDS	SSV SYSTEM DISPERSIONS	ELEMENT VARIATIONS	
WRB	87	47	20	35	24
WS	67	39	33	35	10
HMO	31	28*	11	28*	*
HMI	61	9	5	52**	**
FT01	43	1	26	38	-2
FT02	92	38	12	22	48
FT03	81	37	12	23	33
FT04	81	41	13	18	30
FT06	94	24	10	15	62
FT07	64	12	36	11	27
FT08	64	12	39	10	24
FTB 1,2	90	3	10	19	60
FTB 3,4	93	2	6	10	80
FTB 5,6	28	2	12	1	16
FTB 7,8	81	44	27	27	20
FTB 9,10	93	13	8	10	74
MTB 1,2	88	31	8	13	49

NOTE: $0.90 \leq M \leq 2.0$

* ELEVON LOAD RELIEF AT 400K IN-LBS

** ELEVON LOAD RELIEF AT -500K IN-LBS

FIGURE 190.- MINIMUM INDICATOR MARGINS/WING ROOT BENDING

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

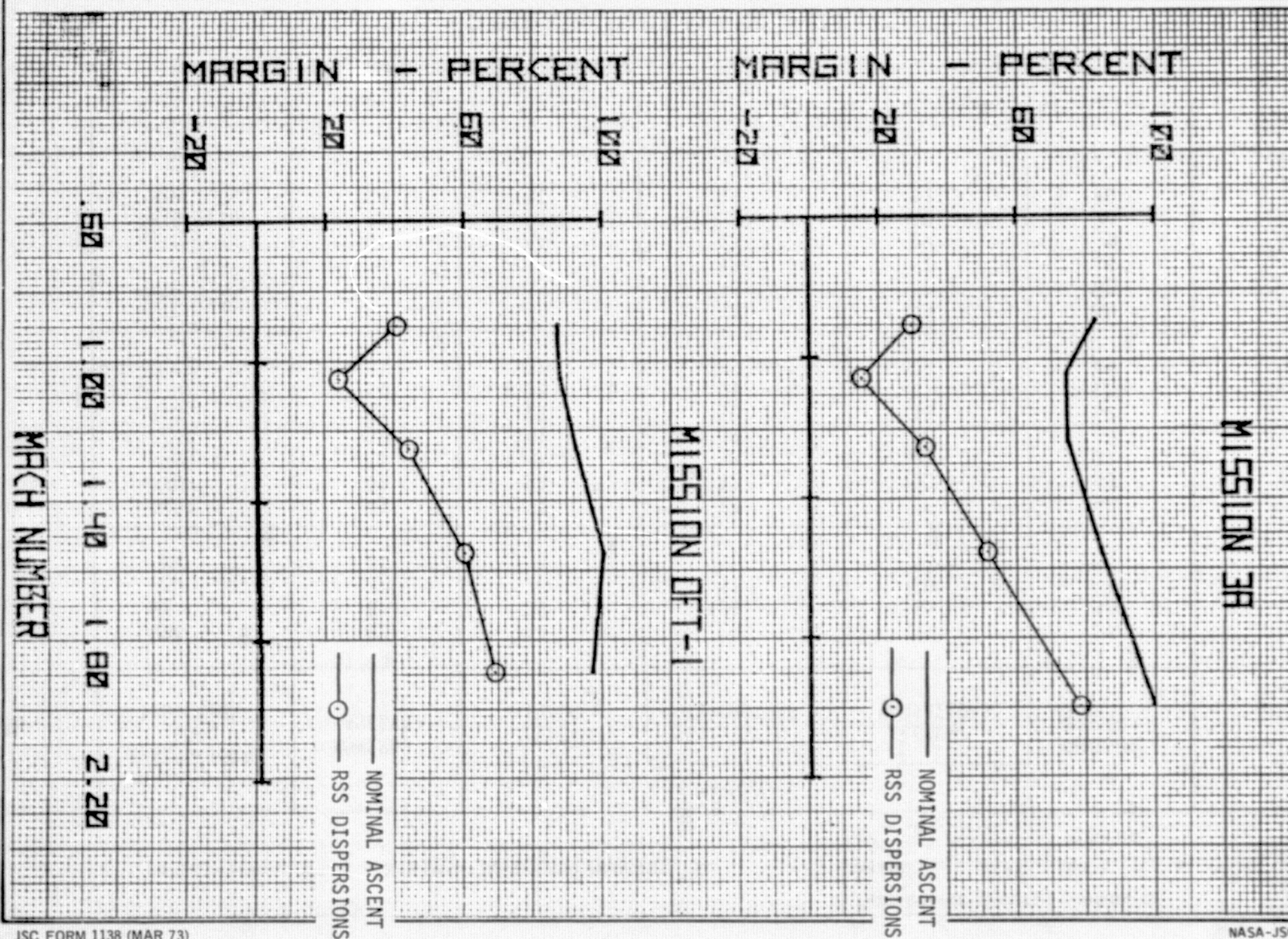


FIGURE 191.- MINIMUM INDICATOR MARGINS/WING SHEAR

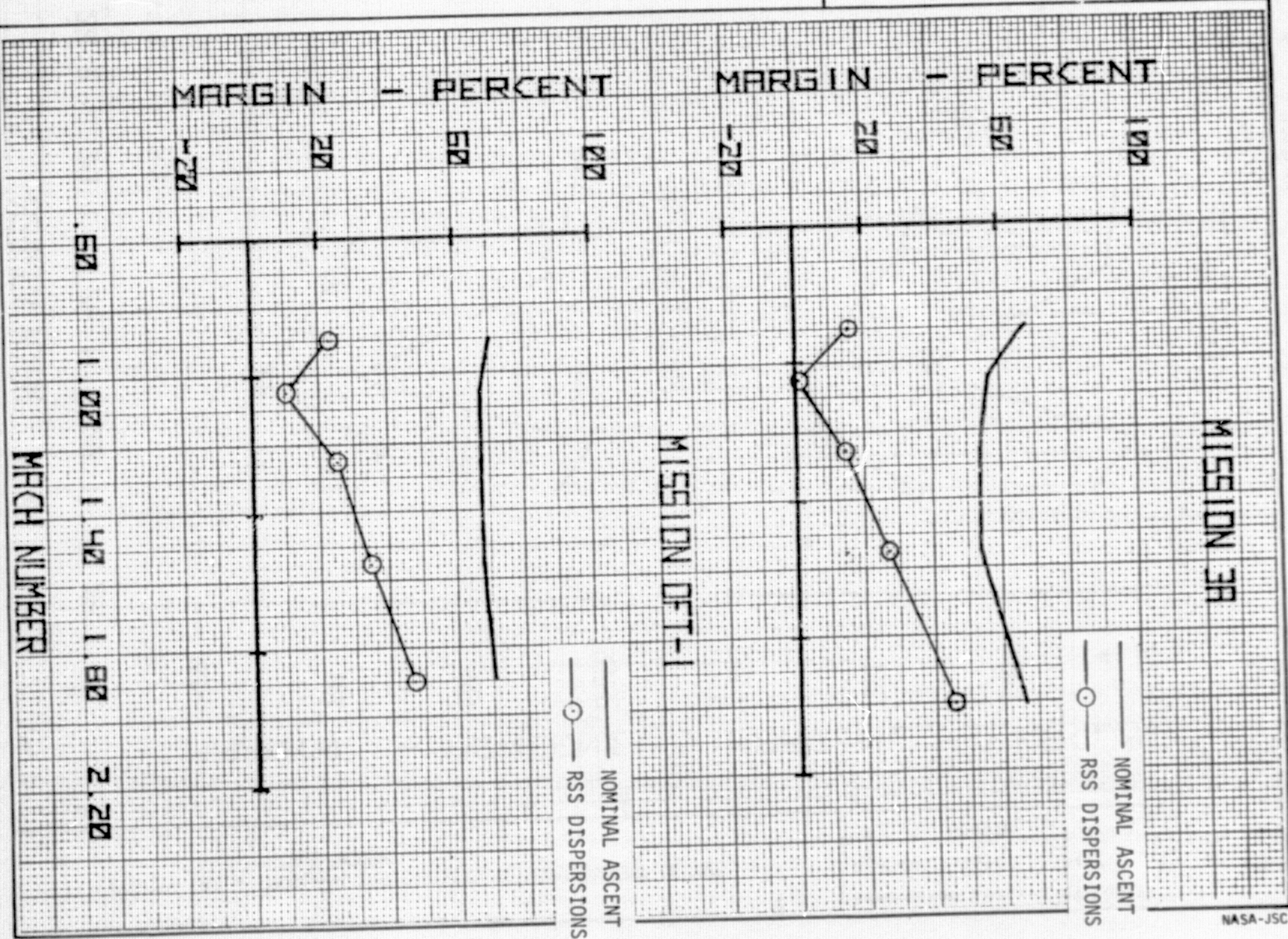
ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

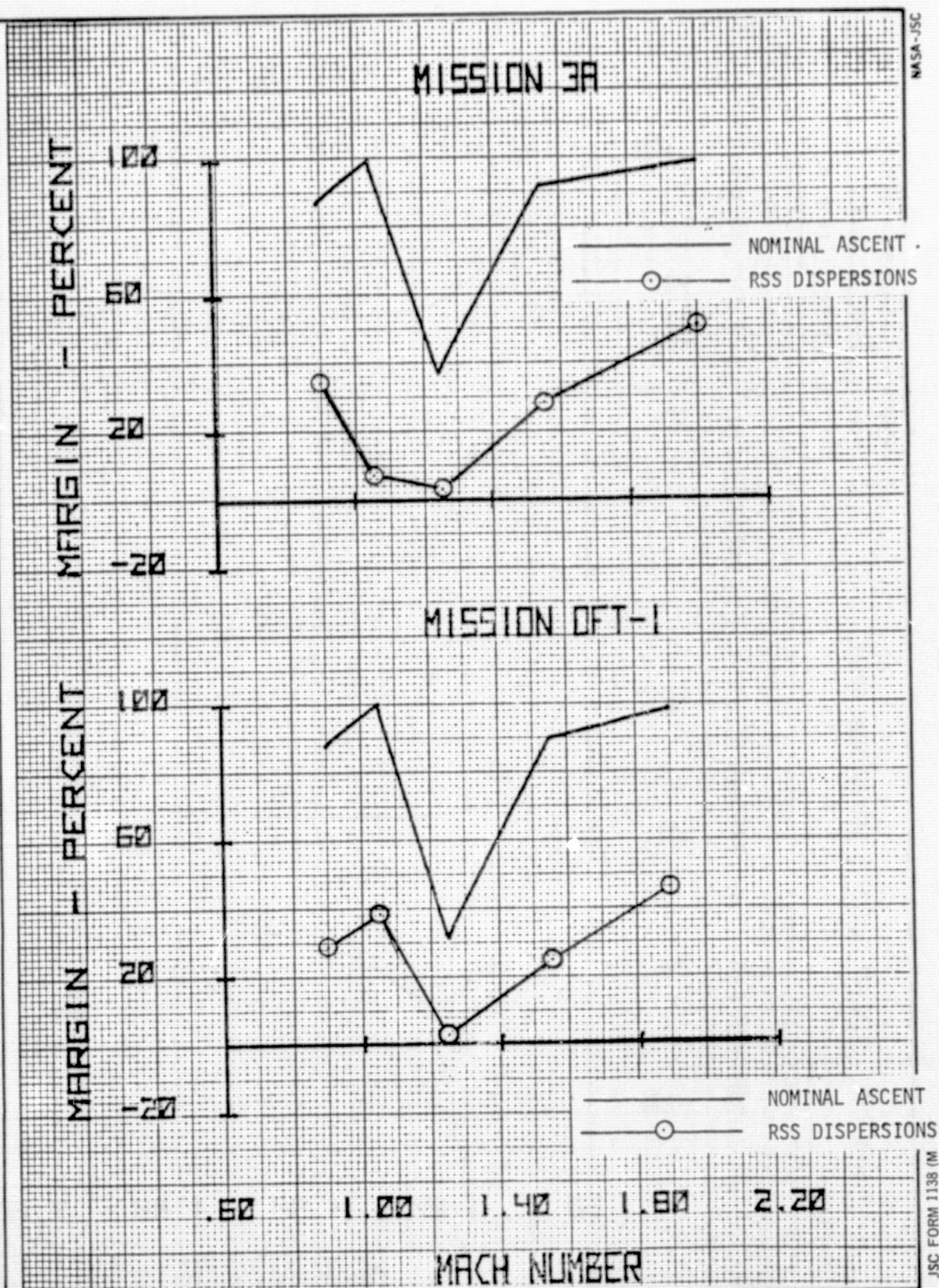
DATE _____

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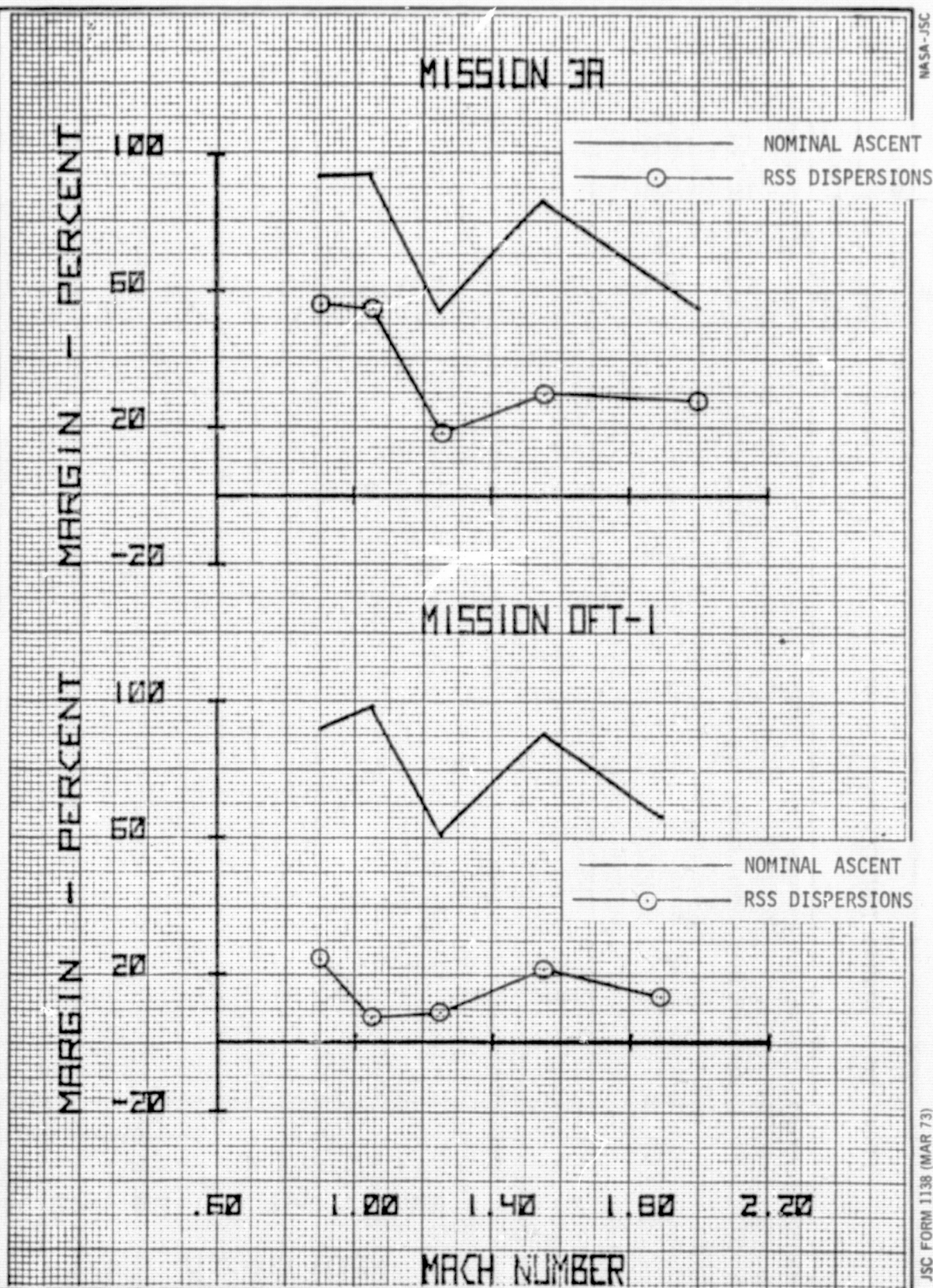
FIGURE 192.- MINIMUM INDICATOR MARGINS/OUTBOARD ELEVON
HINGE MOMENT

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

FIGURE 193.- MINIMUM INDICATOR MARGINS/INBOARD ELEVON HINGE MOMENT

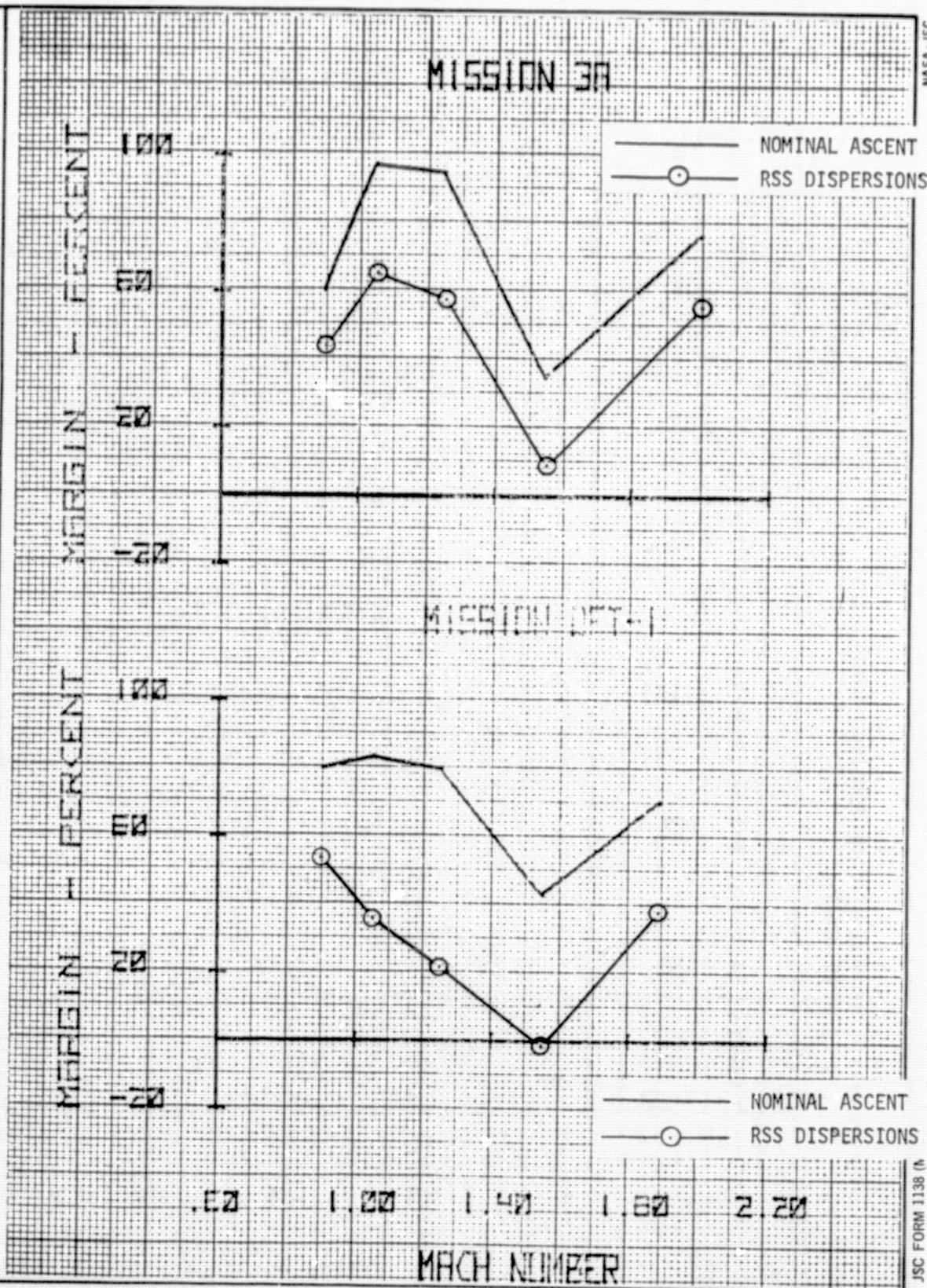


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FIGURE 194.- MINIMUM INDICATOR MARGINS/FT01



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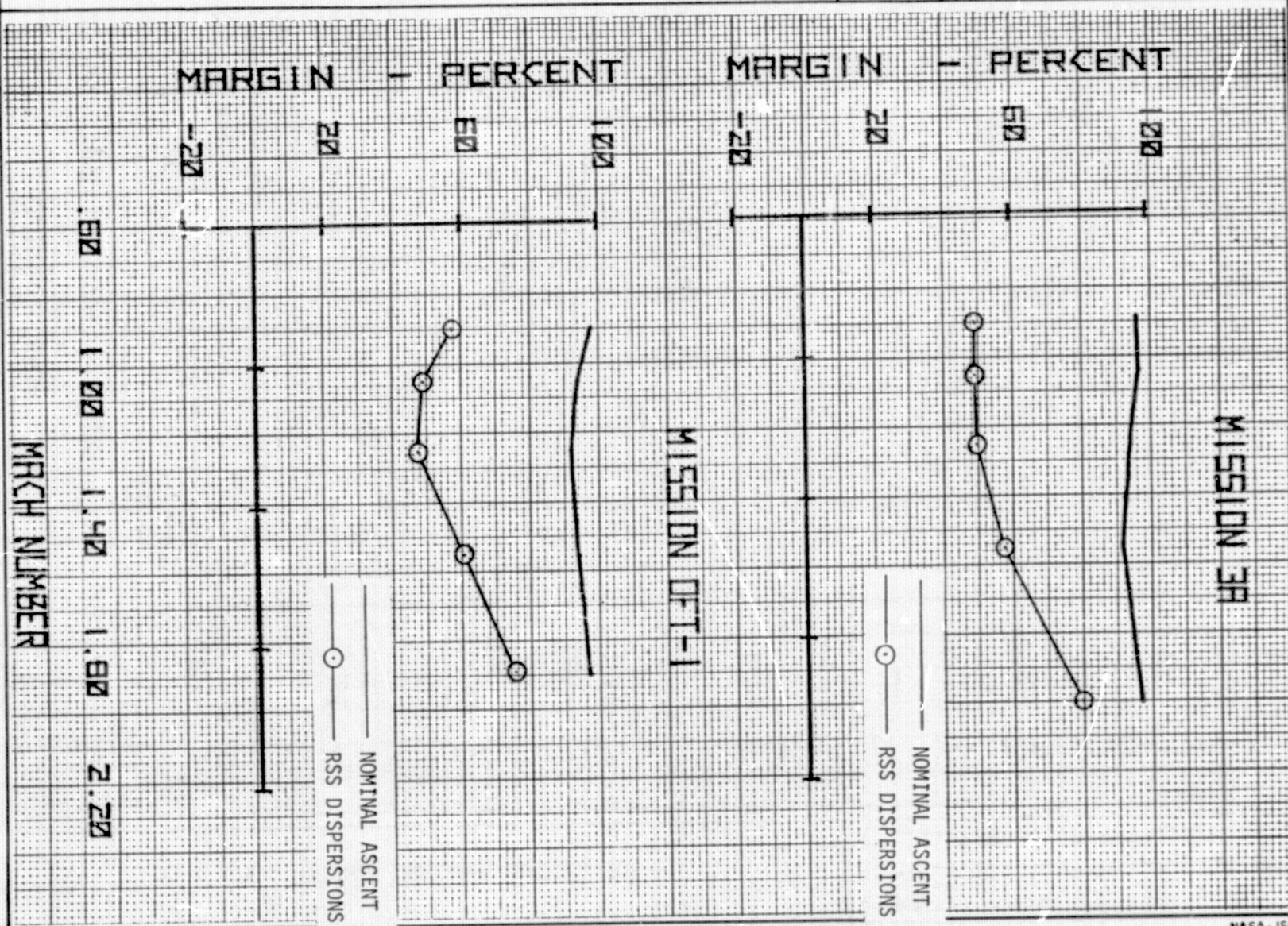
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FIGURE 195.- MINIMUM INDICATOR MARGINS/FT02

ENGINEERING ANALYSIS DIVISION/EX

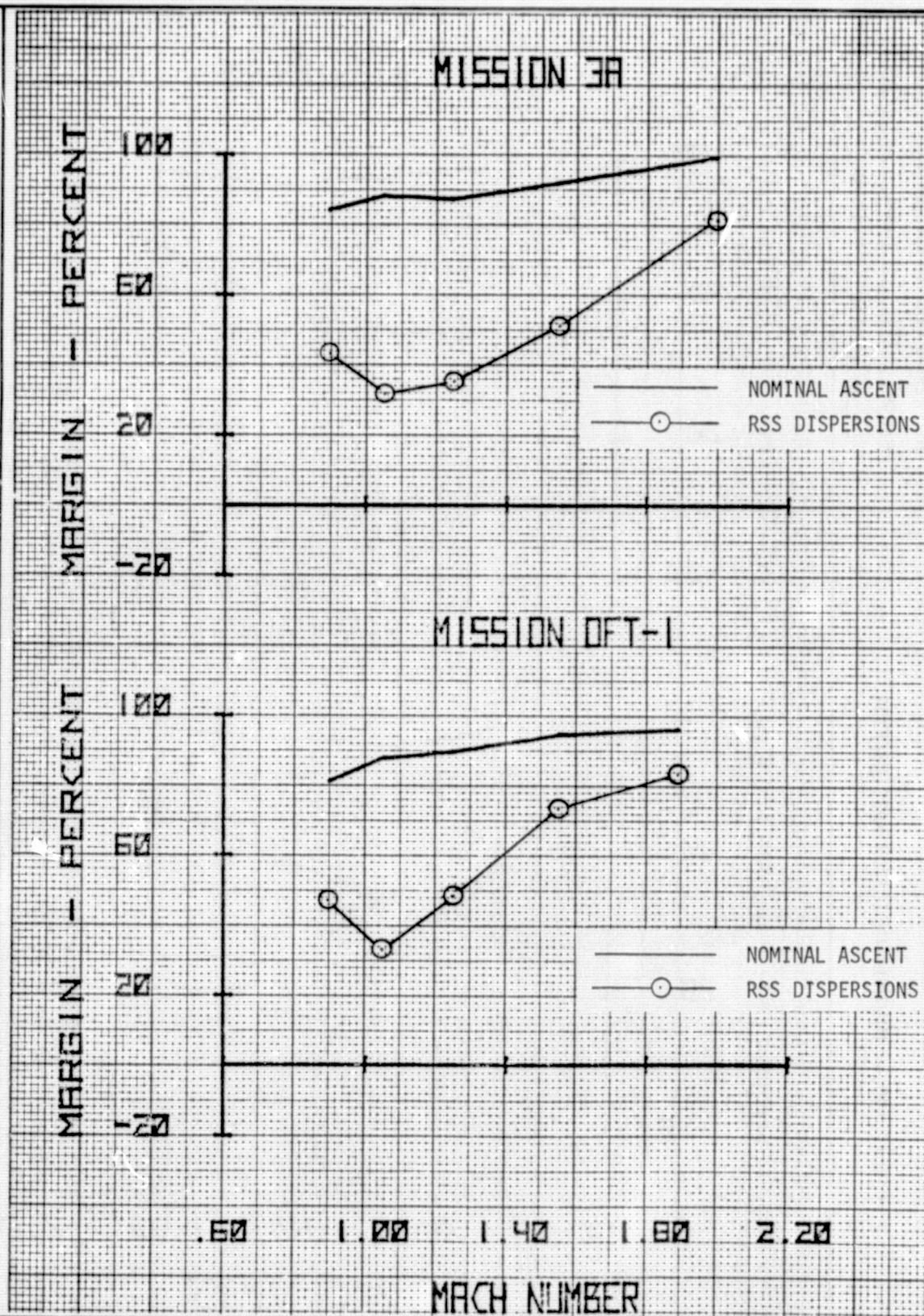
BRANCH EX42 DATE _____

BY L. Austin PLOT NO. _____



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FIGURE 196.- MINIMUM INDICATOR MARGINS/FT03

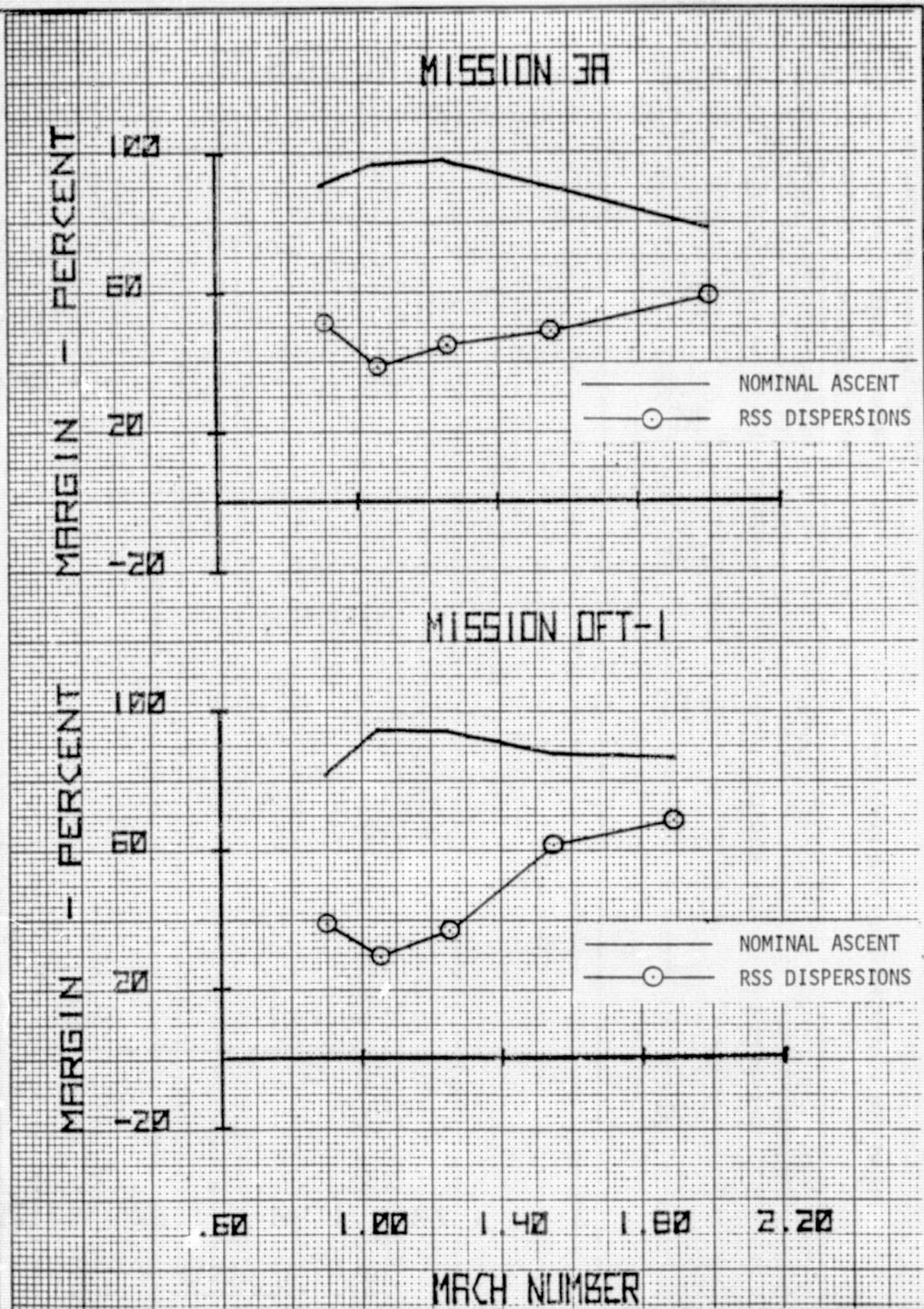


ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

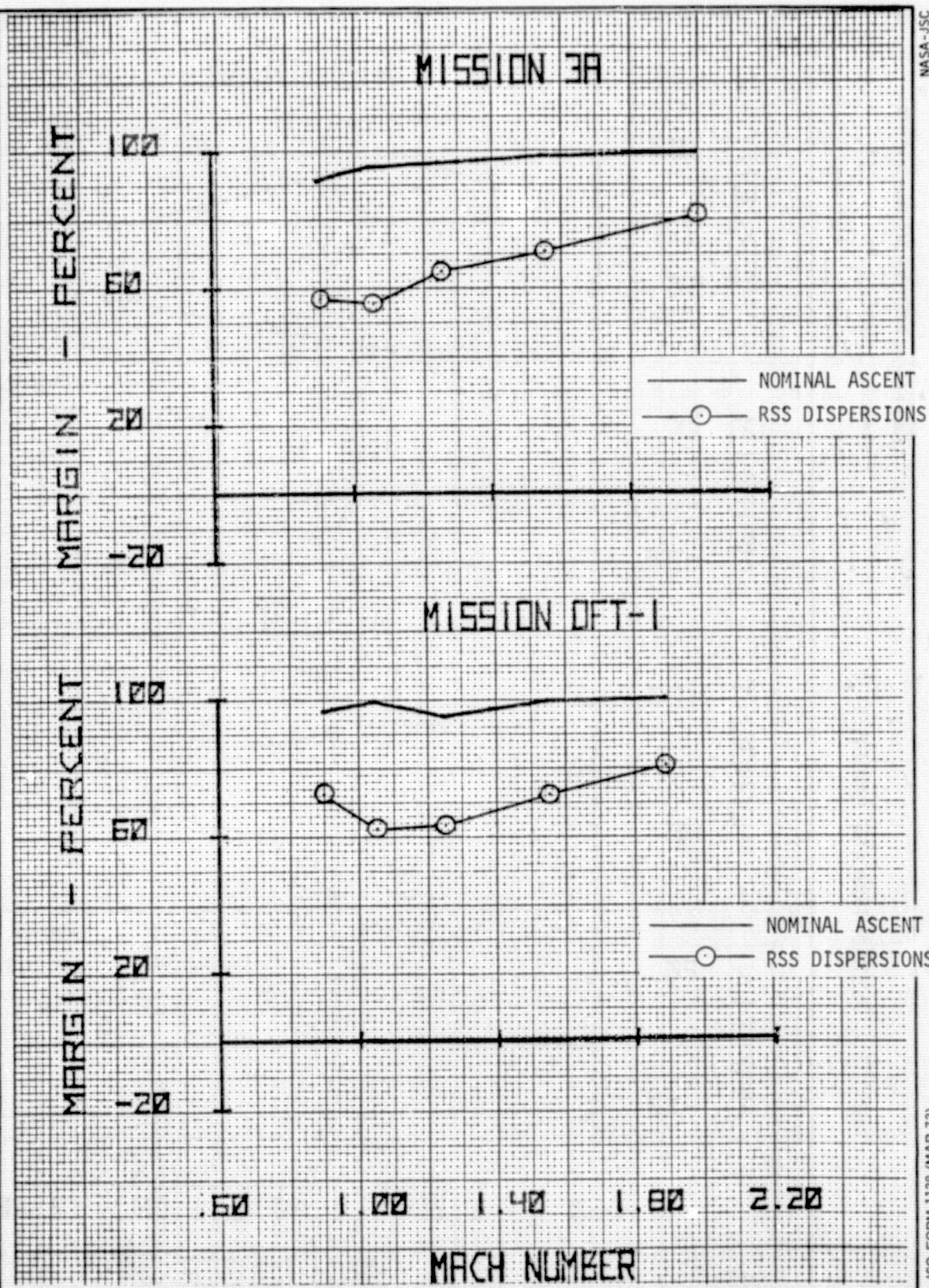
FIGURE 197.- MINIMUM INDICATOR MARGINS/FT04



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FIGURE 198.- MINIMUM INDICATOR MARGINS/FT06



NASA-JSC

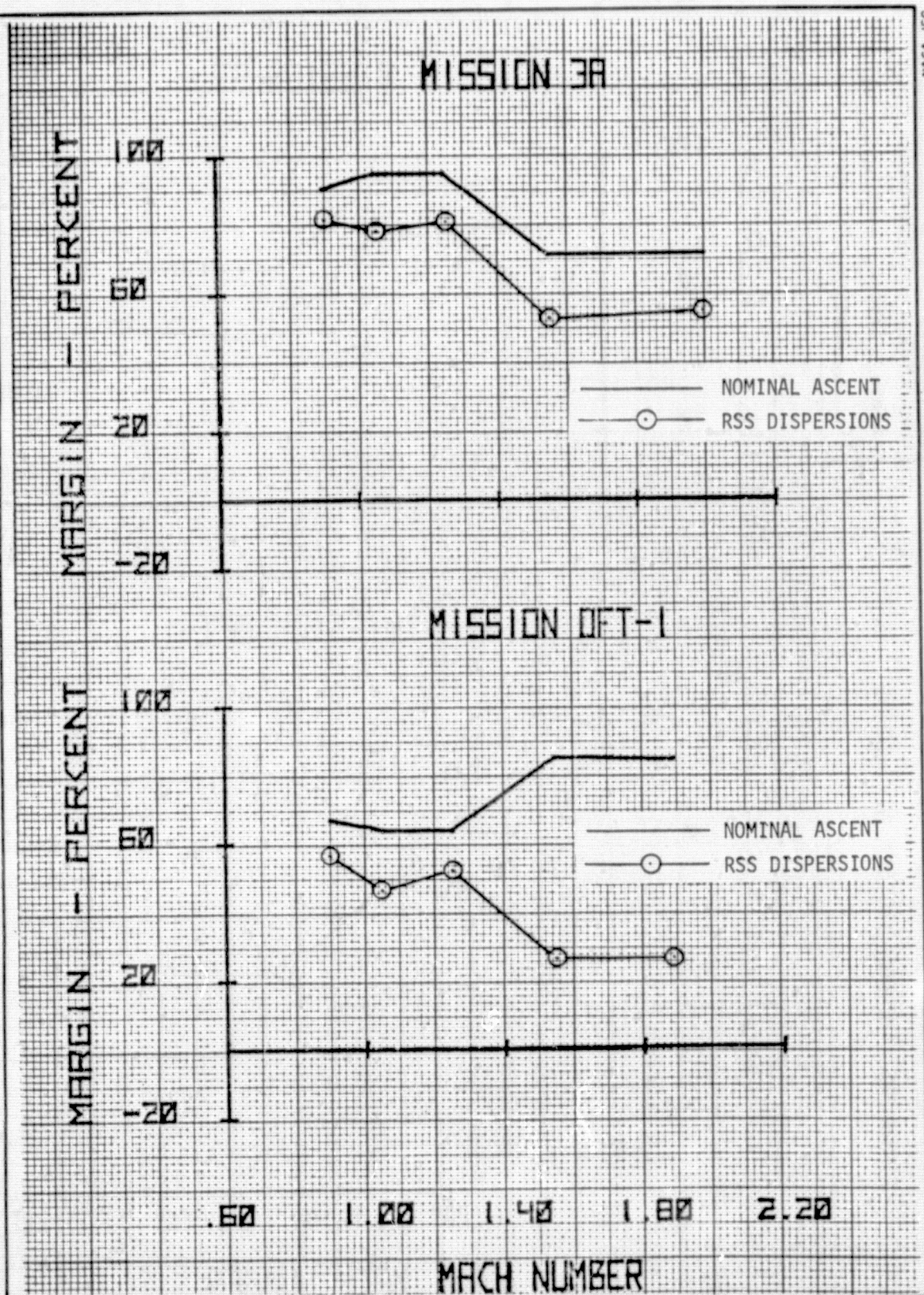
JSC FORM 1138 (MAR 73)

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

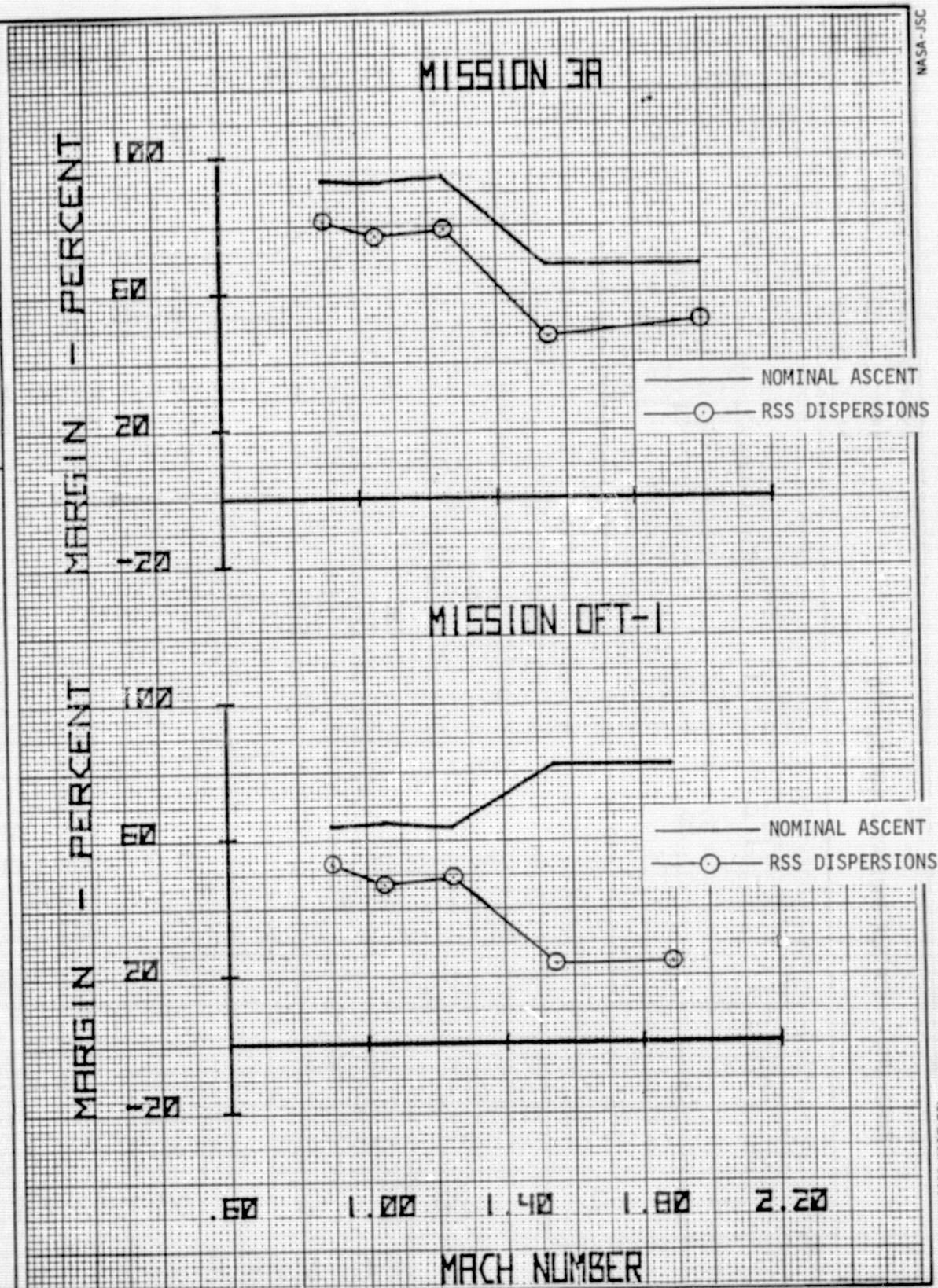
FIGURE 199.- MINIMUM INDICATOR MARGINS/FT07



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FIGURE 200.- MINIMUM INDICATOR MARGINS/FT08



NASA-JSC

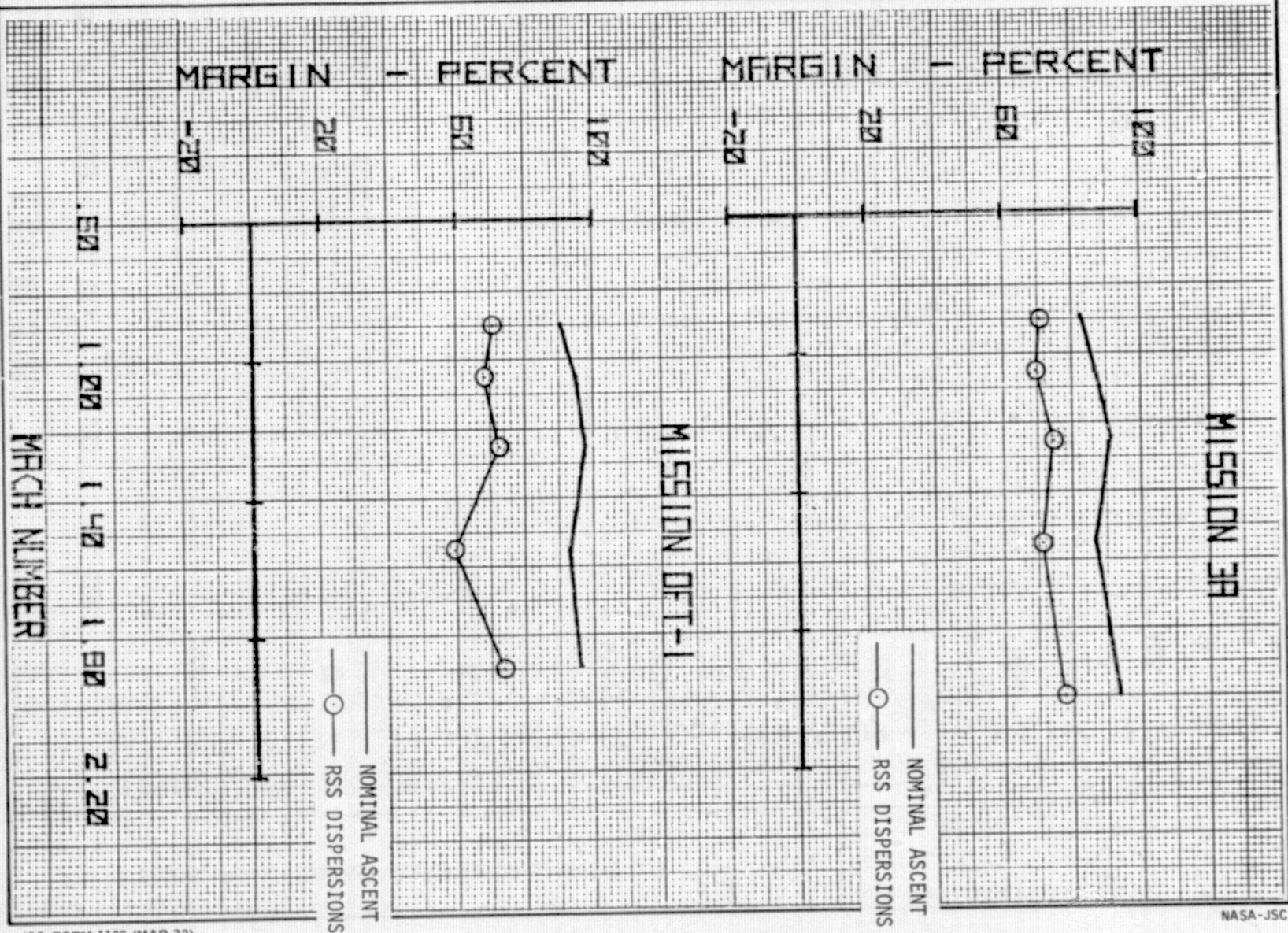
JSC FORM 1138 (MAR 73)

FIGURE 201.- MINIMUM INDICATOR MARGINS/FTB 1,2

ENGINEERING ANALYSIS DIVISION/EX

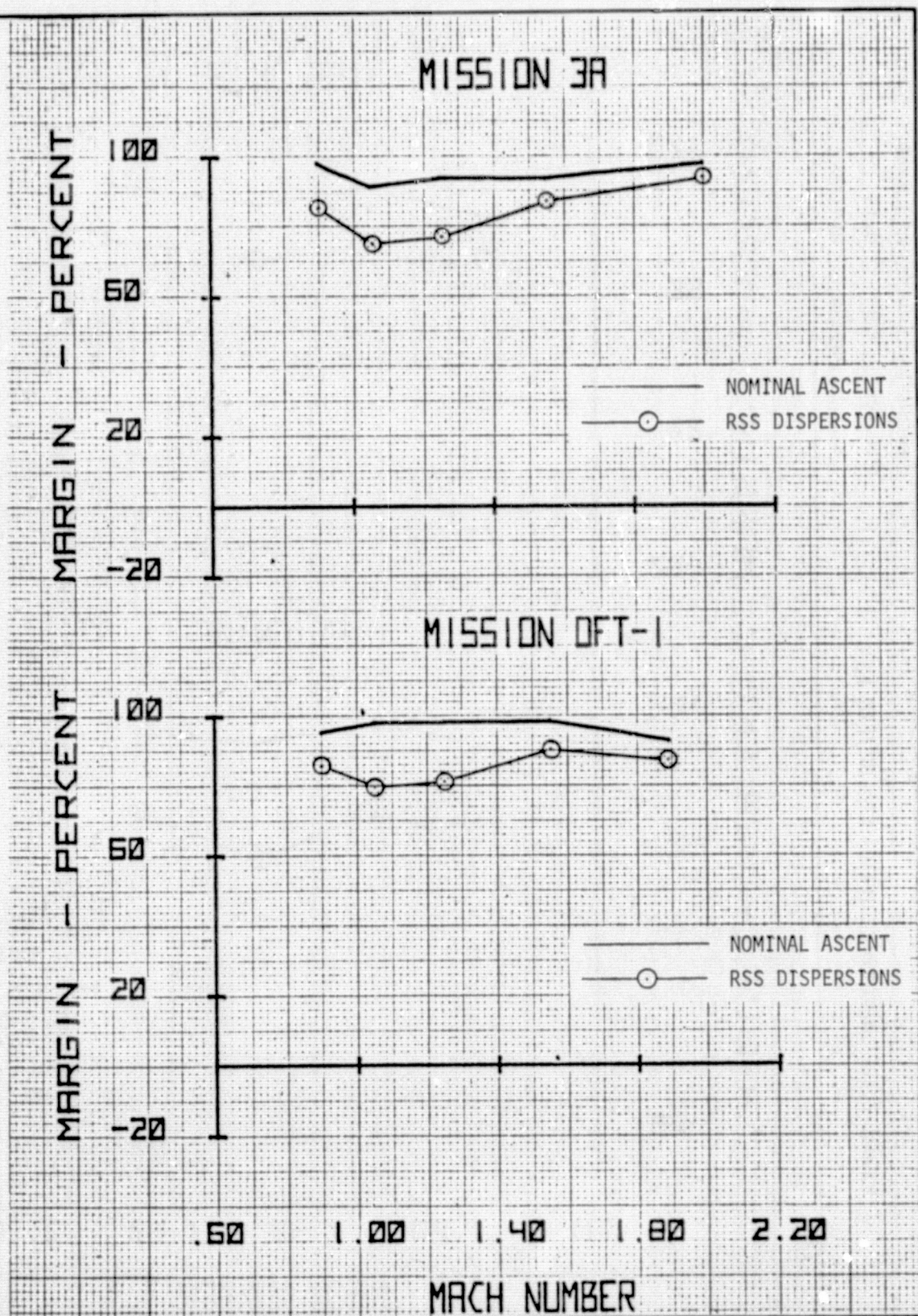
BRANCH EX42 DATE

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FIGURE 202.- MINIMUM INDICATOR MARGINS/FTB 3,4



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JSC FORM 1138 (MAR 73)

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

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FIGURE 203.- MINIMUM INDICATOR MARGINS/FTB 5,6

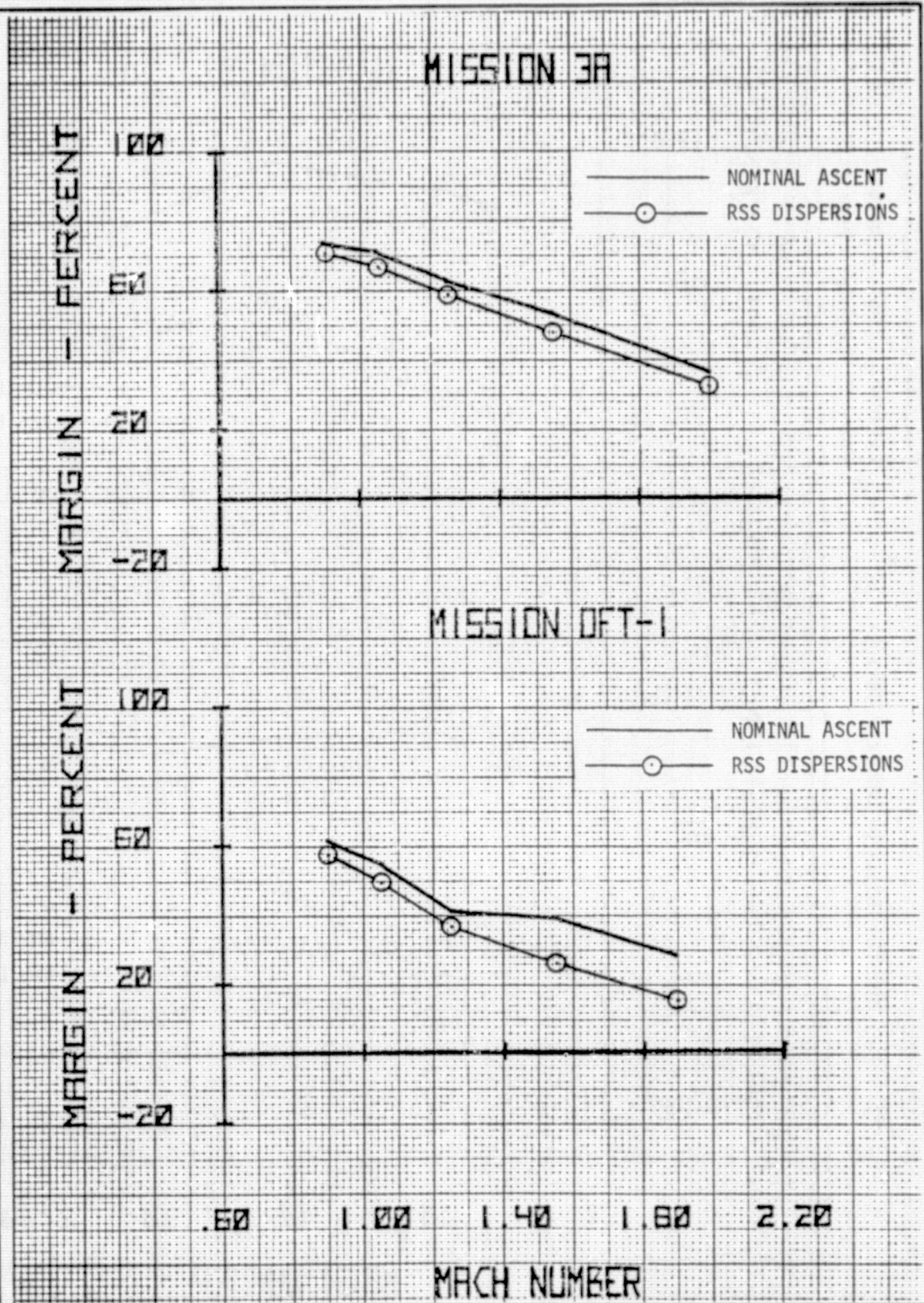


FIGURE 204.- MINIMUM INDICATOR MARGINS/FTB 7,8

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE _____

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PLOT NO. _____

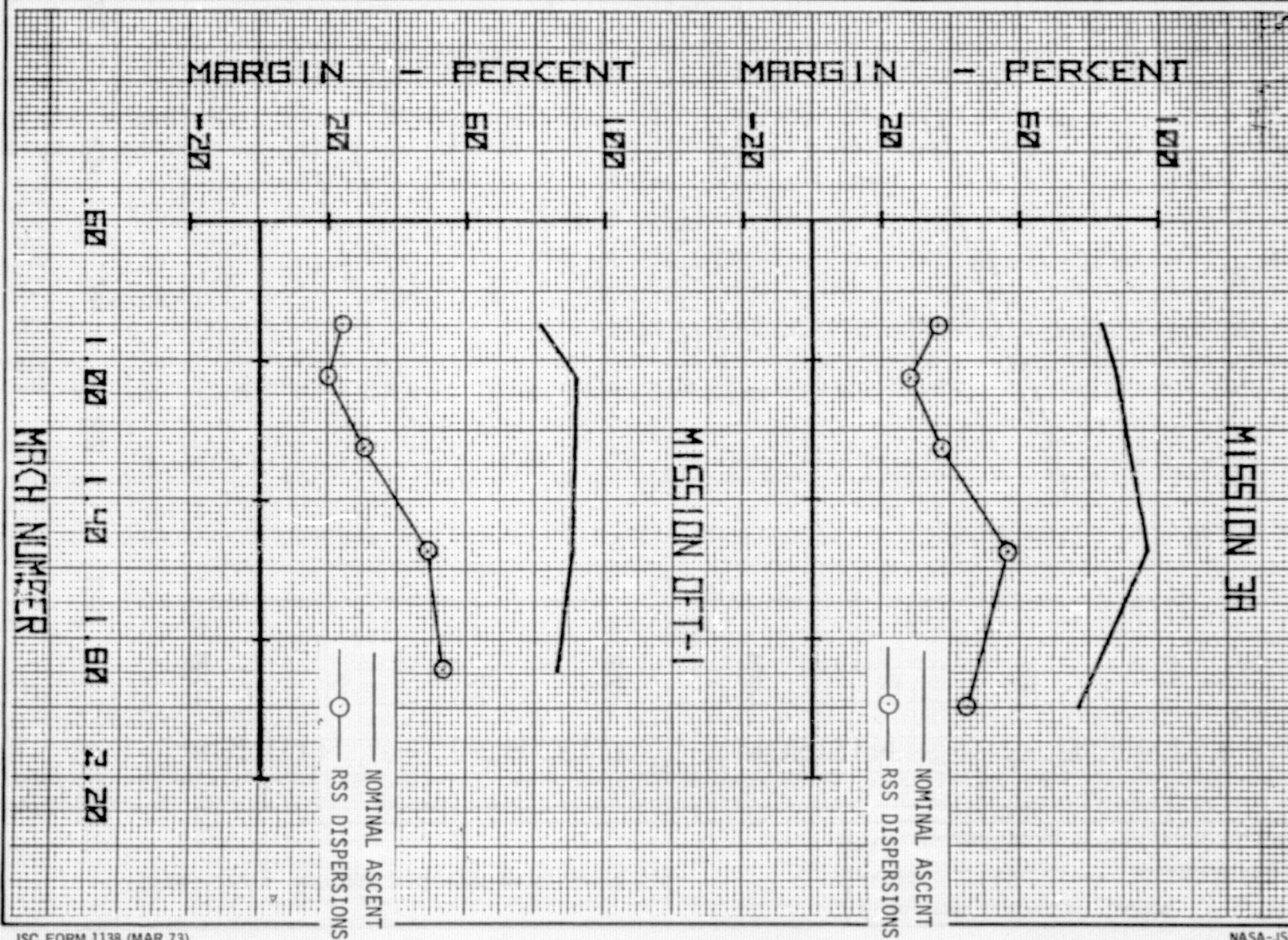
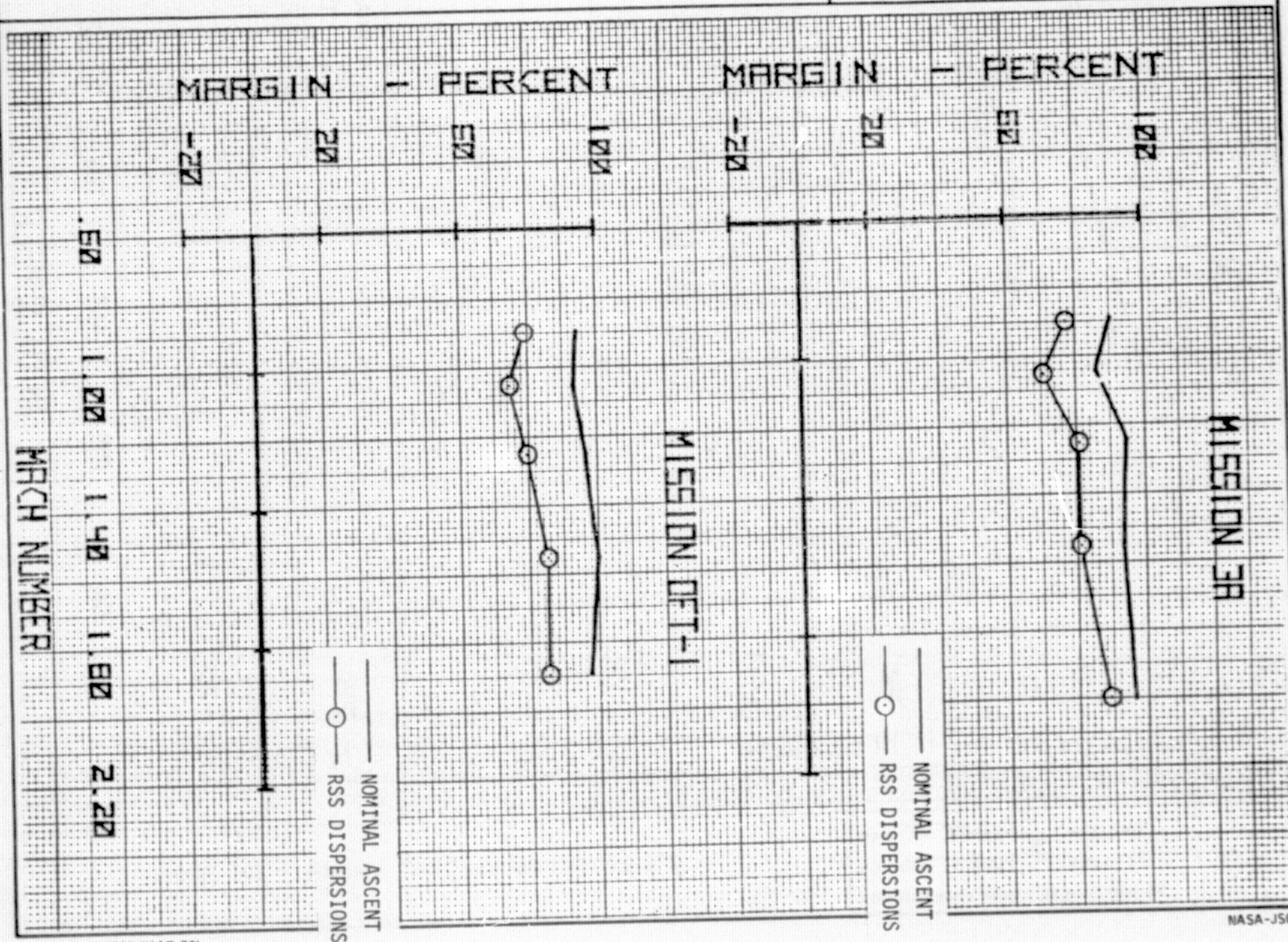


FIGURE 205.- MINIMUM INDICATOR MARGINS/FTB 9,10

ENGINEERING ANALYSIS DIVISION/EX

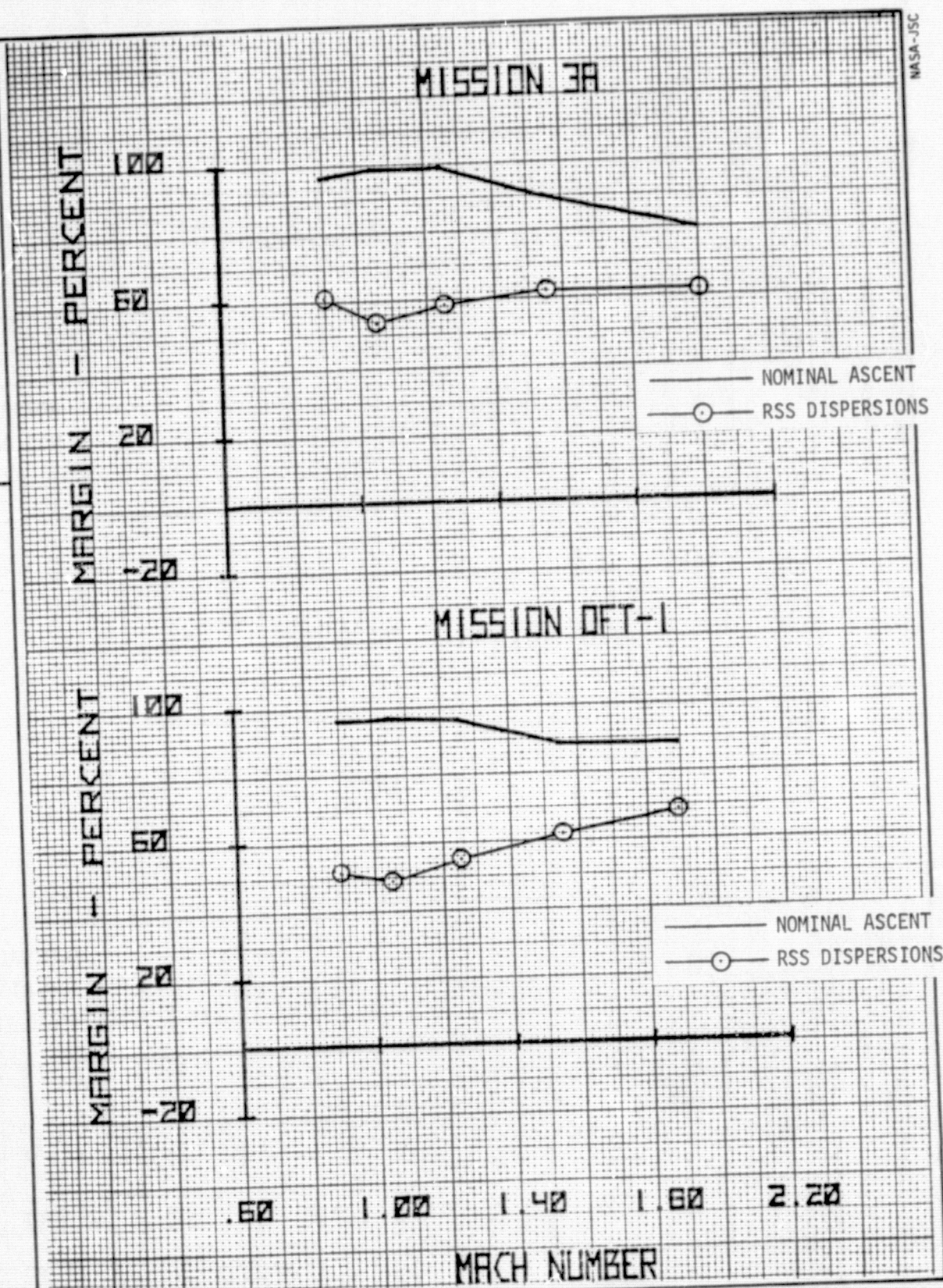
BRANCH EX42 DATE

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FIGURE 206.- MINIMUM INDICATOR MARGINS/MTB 1,2



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FIGURE A-1.- OFT-1/3A SQUATCHELOID COMPARISON

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX4 DATE

BY L. Austin PLOT NO.

MACH $\approx$ 1.05

FCS 7

○ MISSION 3A/95 PERCENTILE

◇ OFT-1/95 PERCENTILE

△ OFT-1/50 PERCENTILE

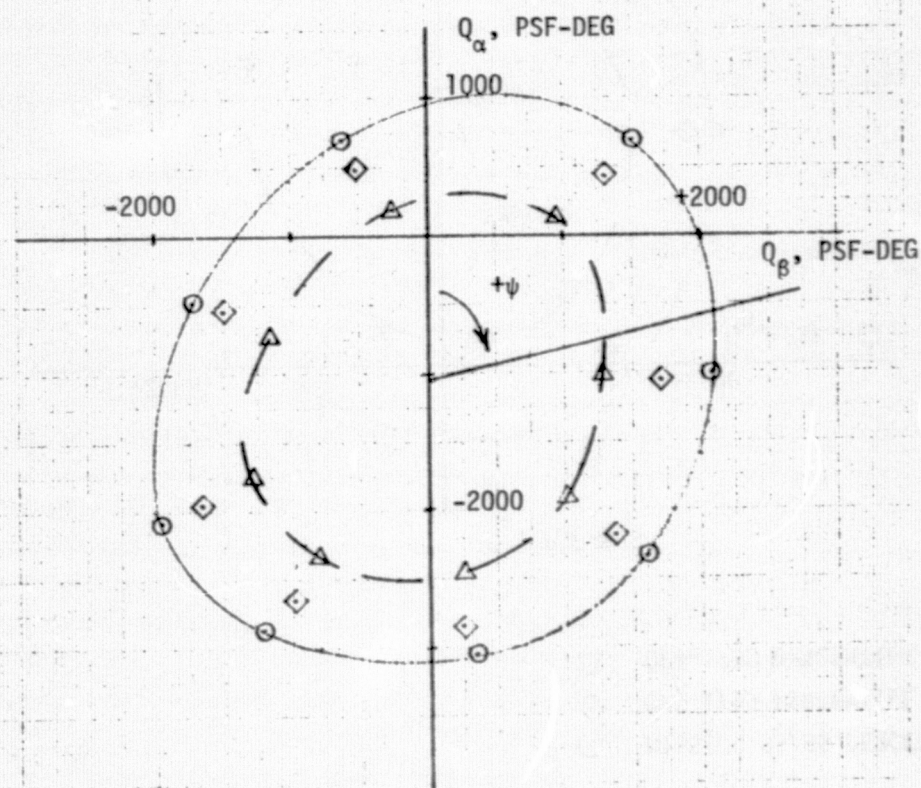


FIGURE A-2.- OFT-1/3A SQUATCHELOIDS

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX4 DATE

BY L. Austin PLOT NO.

MACH = 1.25

FCS 7

○ MISSION 3A/95 PERCENTILE

◇ OFT-1/95 PERCENTILE

△ OFT-1/50 PERCENTILE

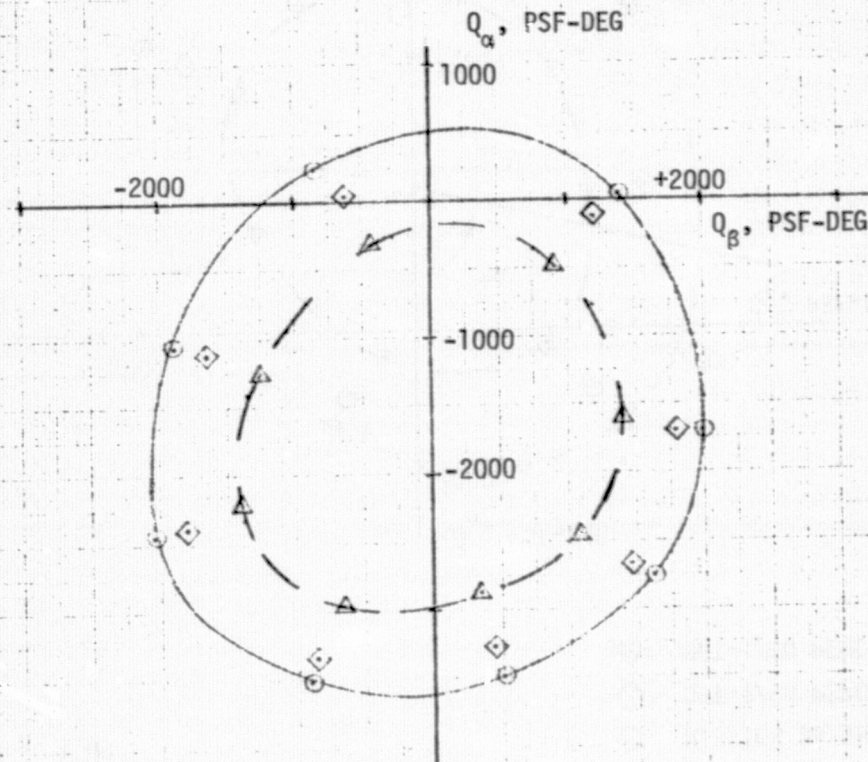


FIGURE A-3.- OBT-1 95% VS 50% WINDS

MACH=1.05

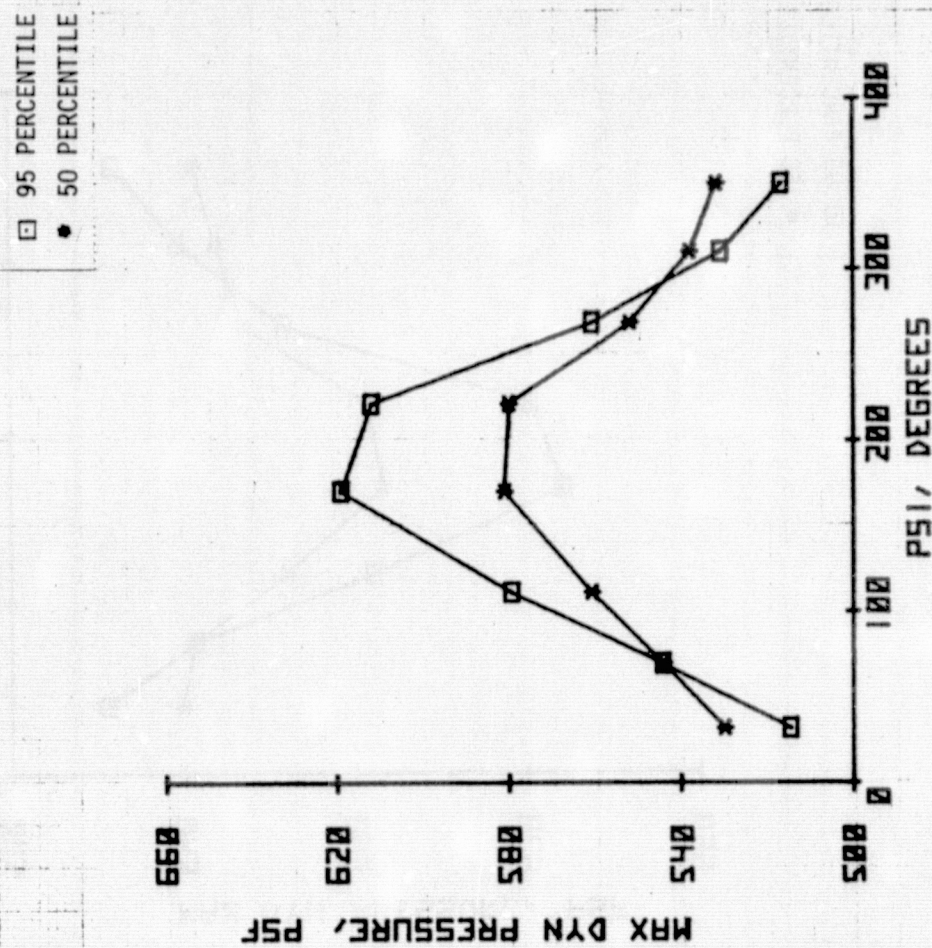


FIGURE A-4.- OFT-I 95% VS 50% WINDS

MACH=1.25

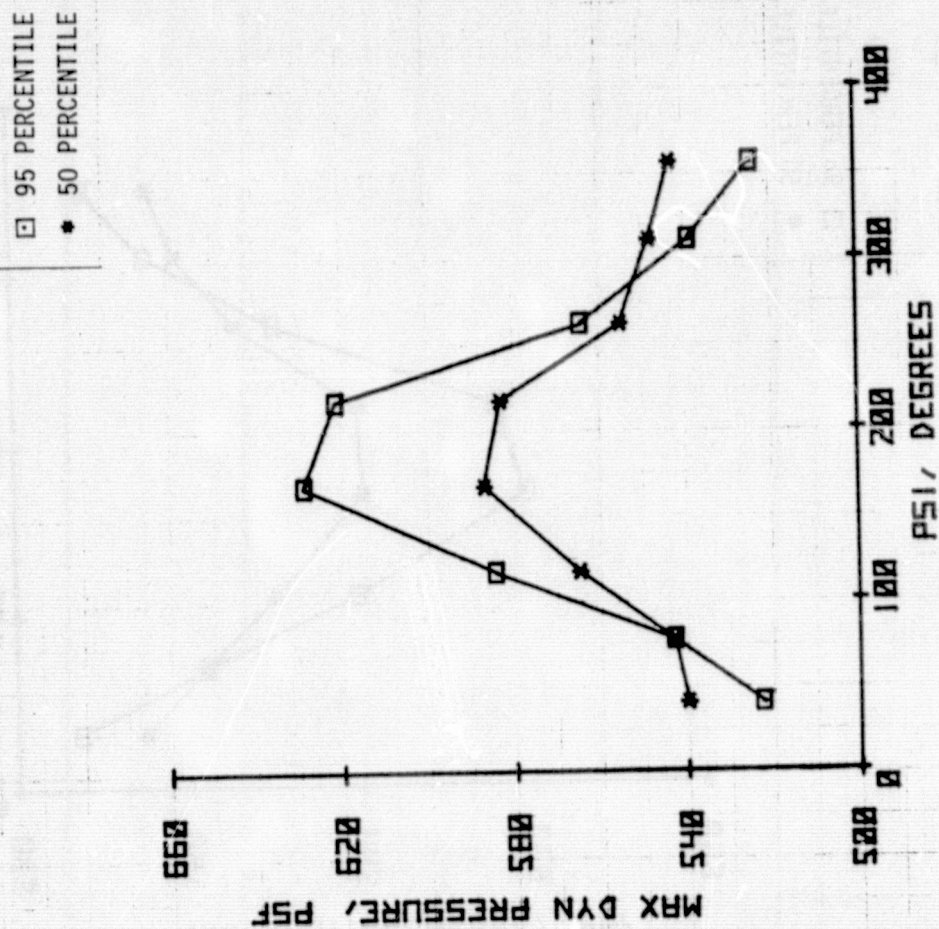


FIGURE A-5.- FLUTTER MARGIN/WORST CASE VECTOR WINDS

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42 DATE

BY L. Austin PLOT NO.

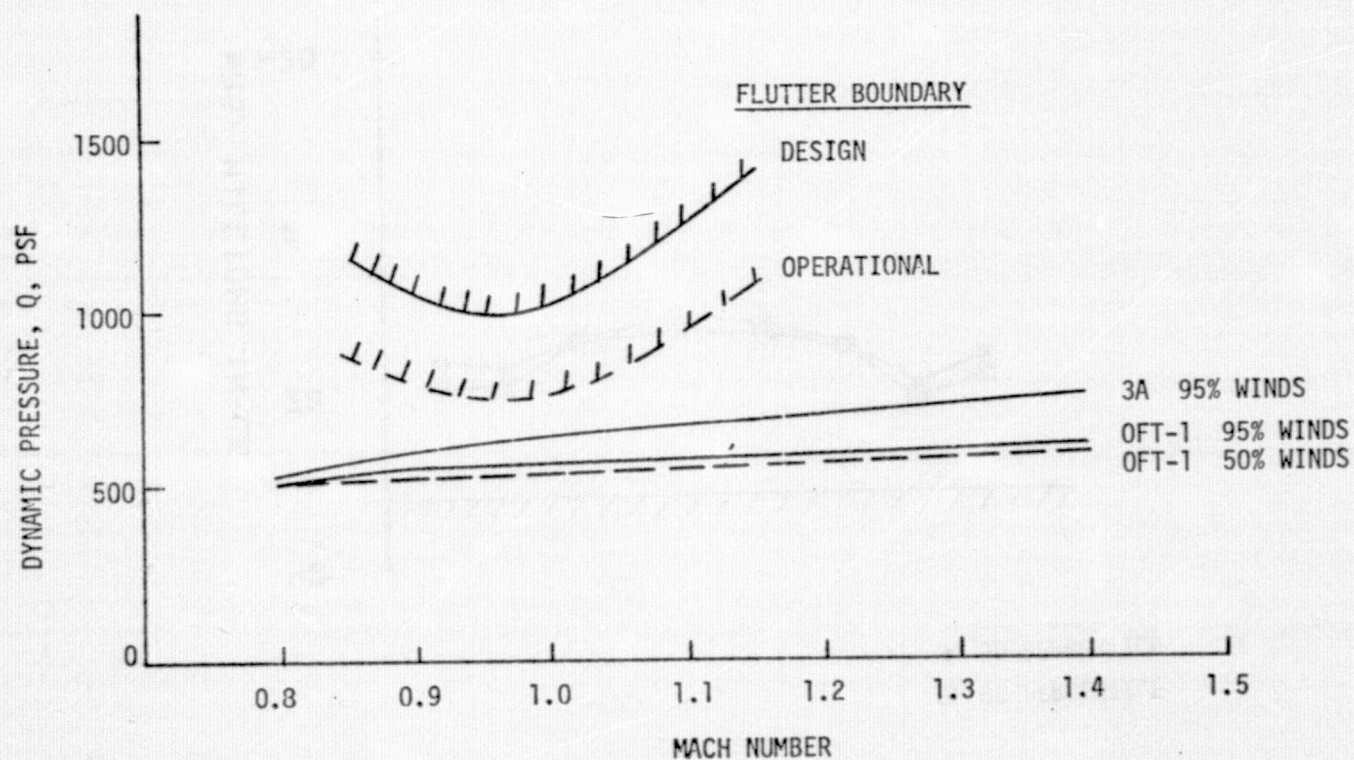


FIGURE A-6.- OFT-1 95% VS 50% WINDS

MACH=1.05

□ 95 PERCENTILE
● 50 PERCENTILE

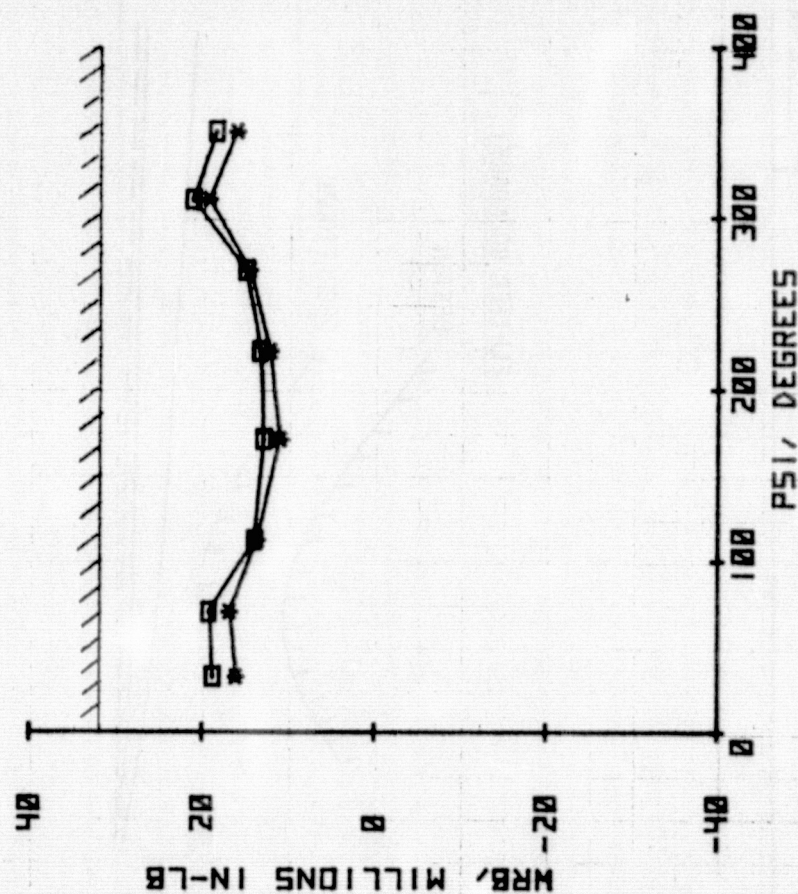


FIGURE A-7.- OBT-1 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
♦ 50 PERCENTILE

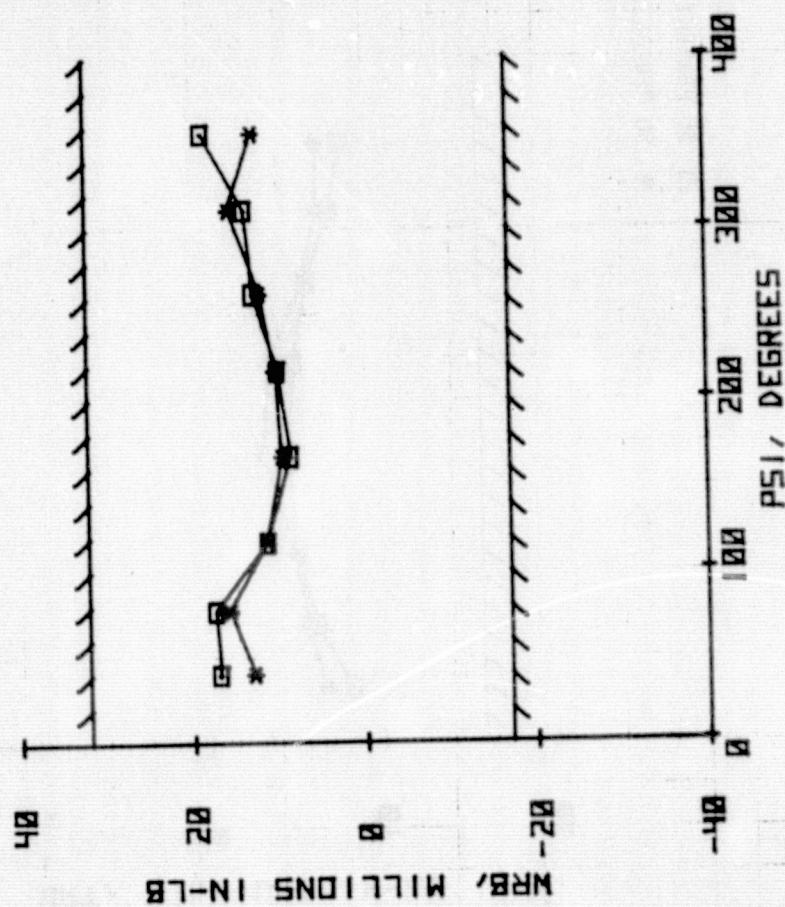


FIGURE A-8.- OFT-I 35% VS 50% WINDS

MACH=1.05

□ 95 PERCENTILE
● 50 PERCENTILE

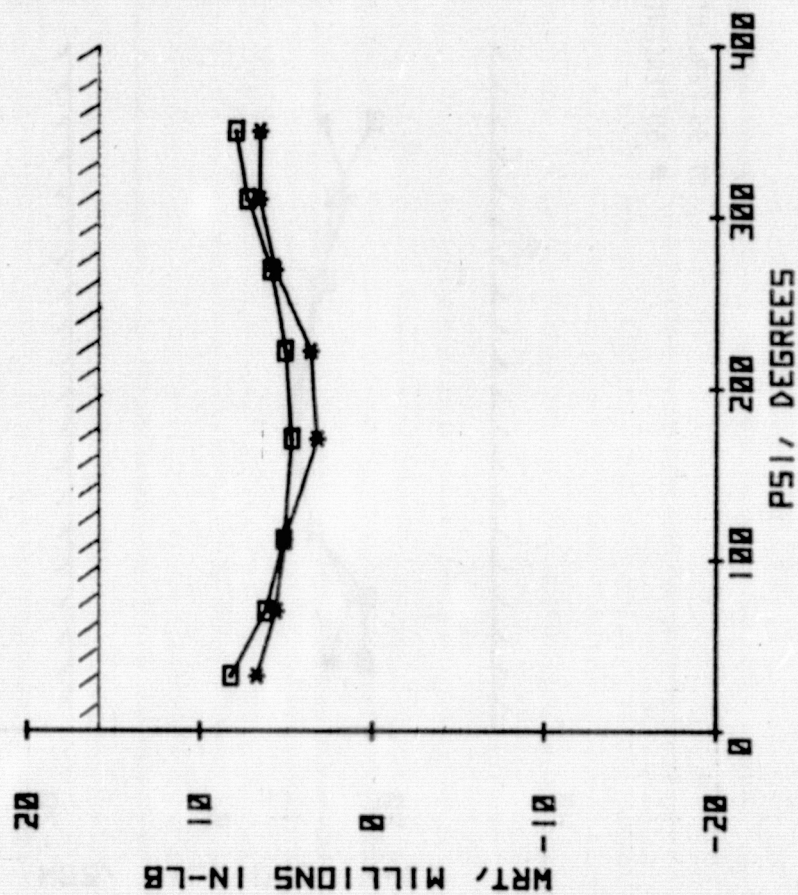


FIGURE A-9.- DFT-1 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
● 50 PERCENTILE

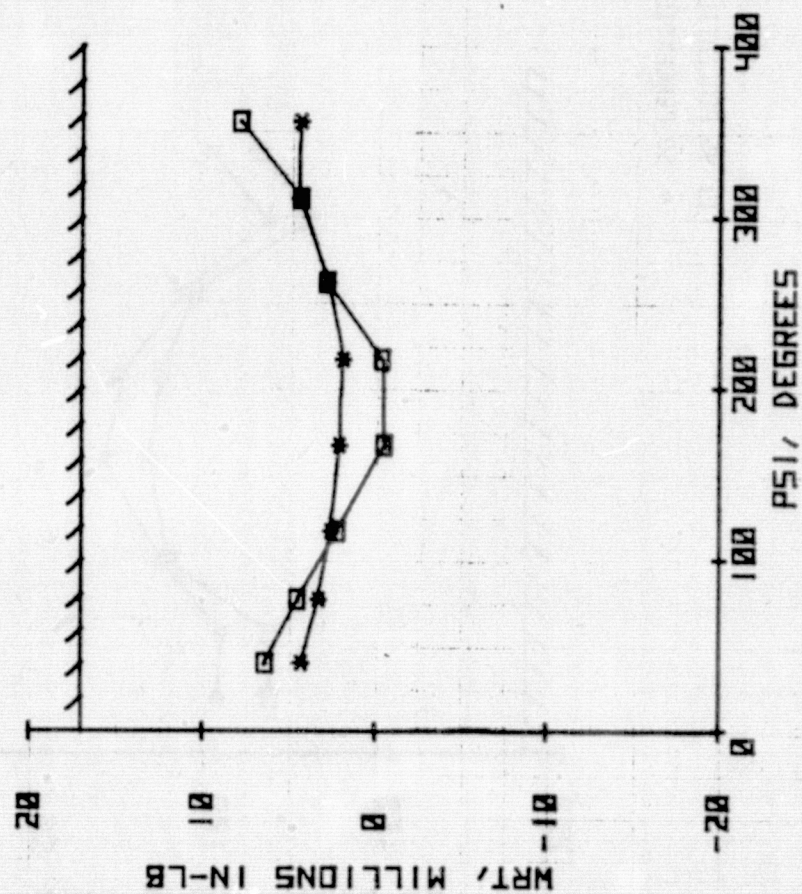


FIGURE A-10.- DFT-1 95% VS 50% WINDS

MACH=1.05

□ 95 PERCENTILE
• 50 PERCENTILE

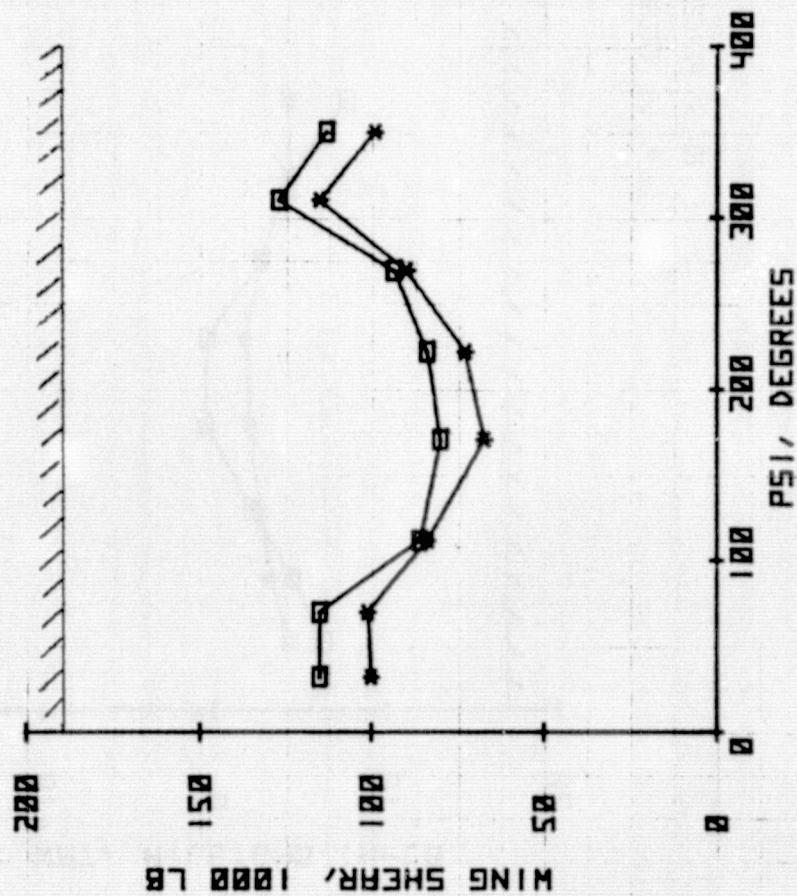


FIGURE A-11.- OFT-I 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
* 50 PERCENTILE

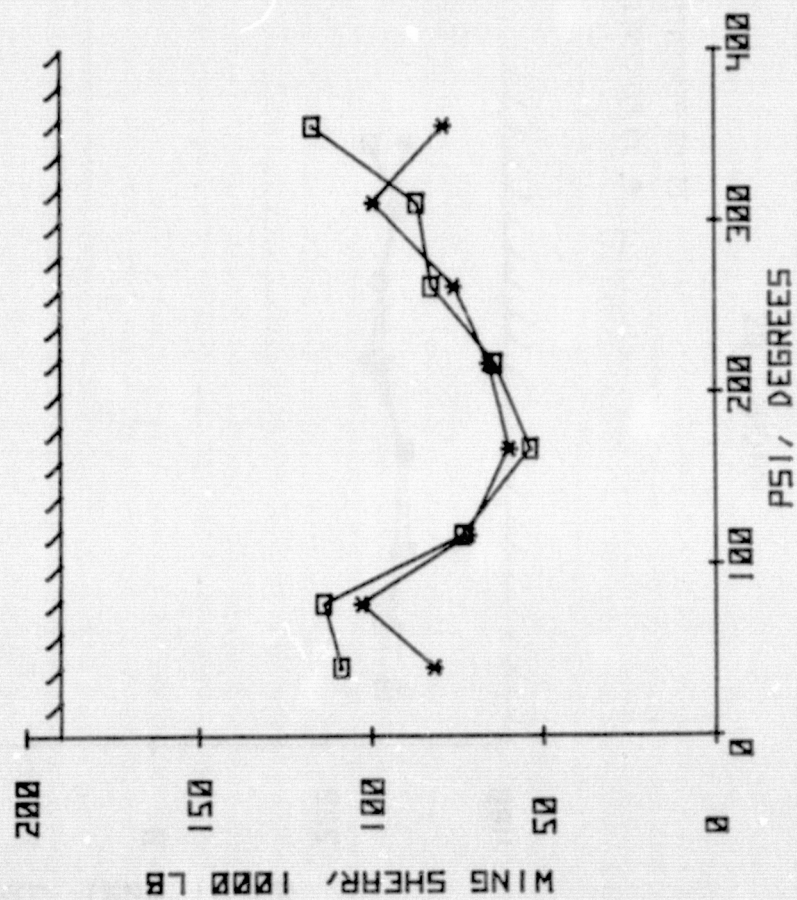


FIGURE A-12.- OFT-1 95% VS 50% WINDS

MACH=1.05

□ 95 PERCENTILE
● 50 PERCENTILE

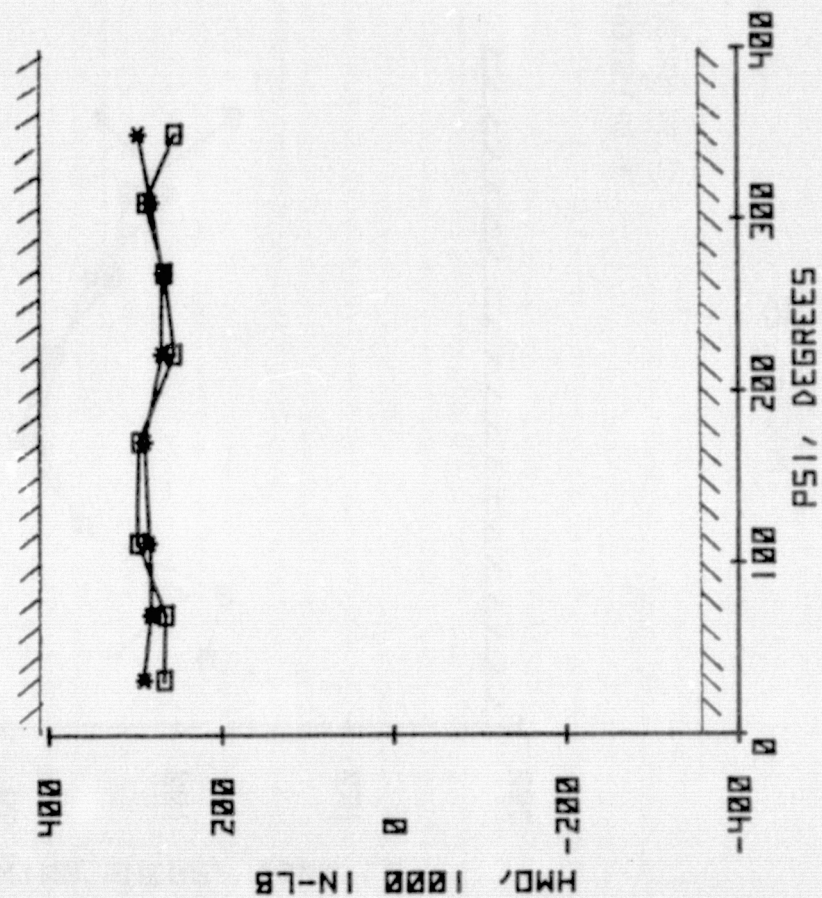


FIGURE A-13.- OFT-I 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
• 50 PERCENTILE

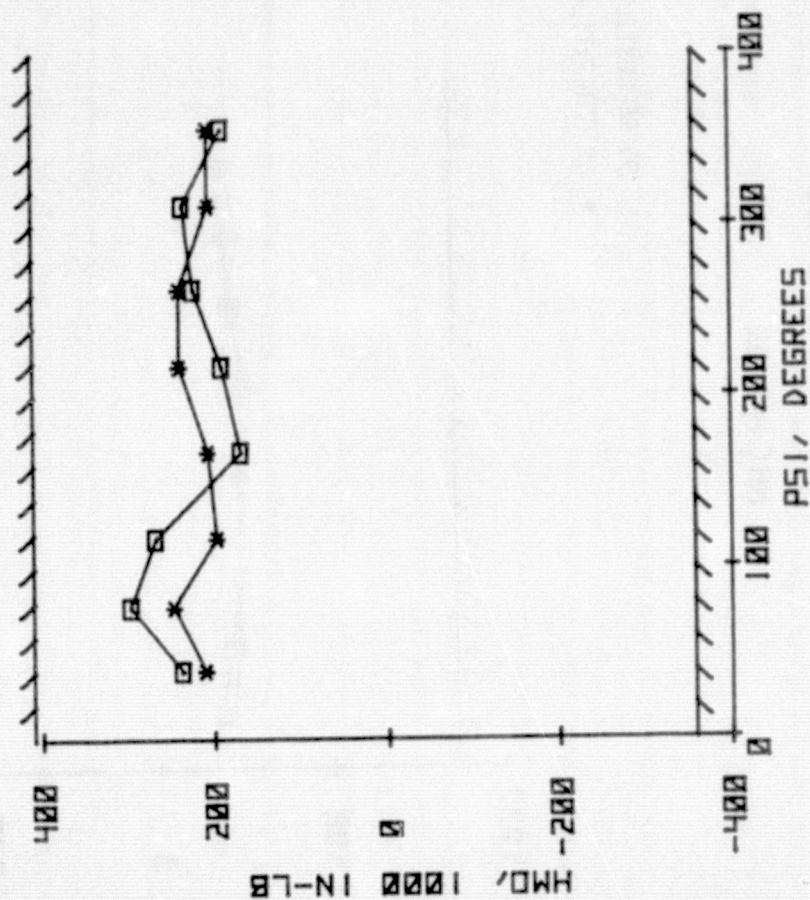


FIGURE A-14.- DFT-1 95% VS 50% WINDS

MACH=1.05

□ 95 PERCENTILE
• 50 PERCENTILE

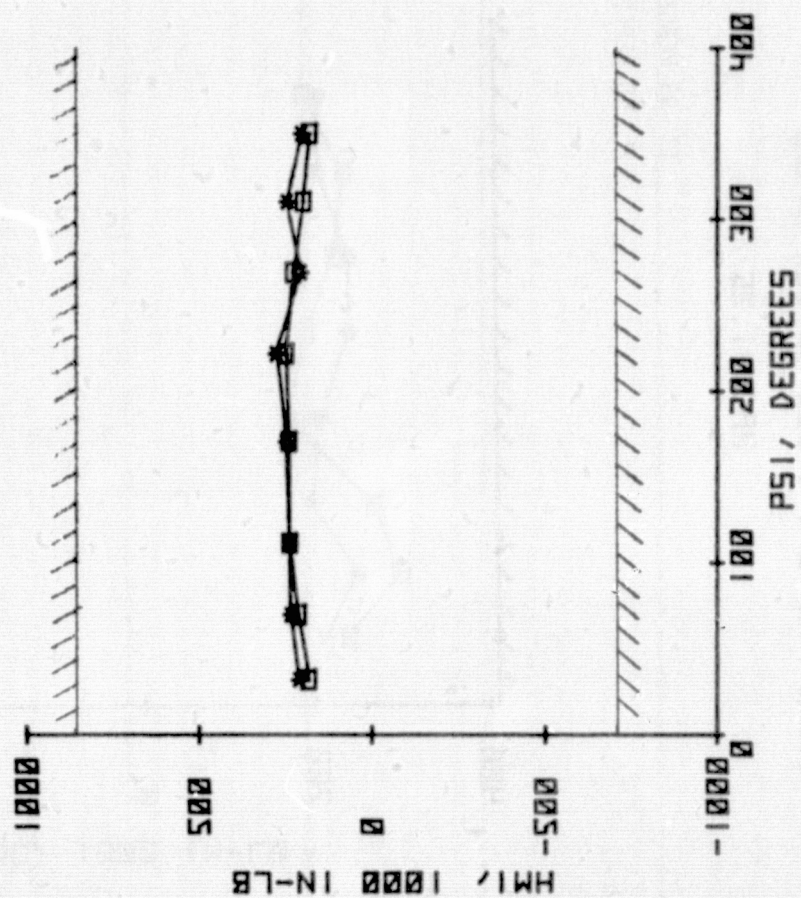


FIGURE A-15.- OFT-I 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
• 50 PERCENTILE

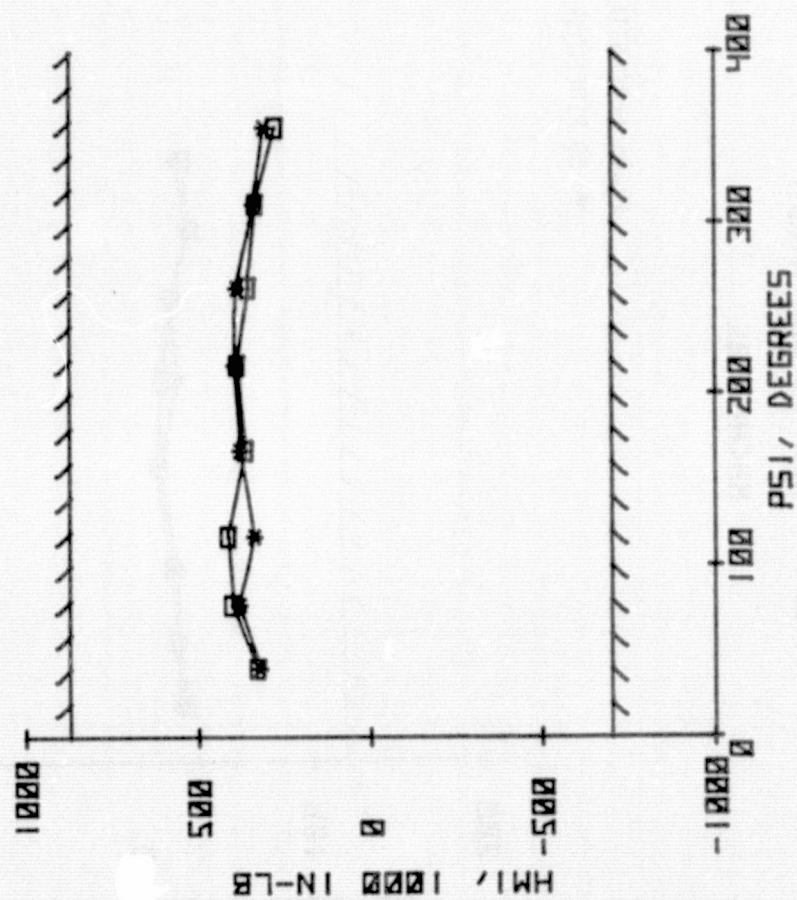


FIGURE A-16.- OFT-I 95% VS 50% WINDS

MACH=1.05

□ 95 PERCENTILE
* 50 PERCENTILE

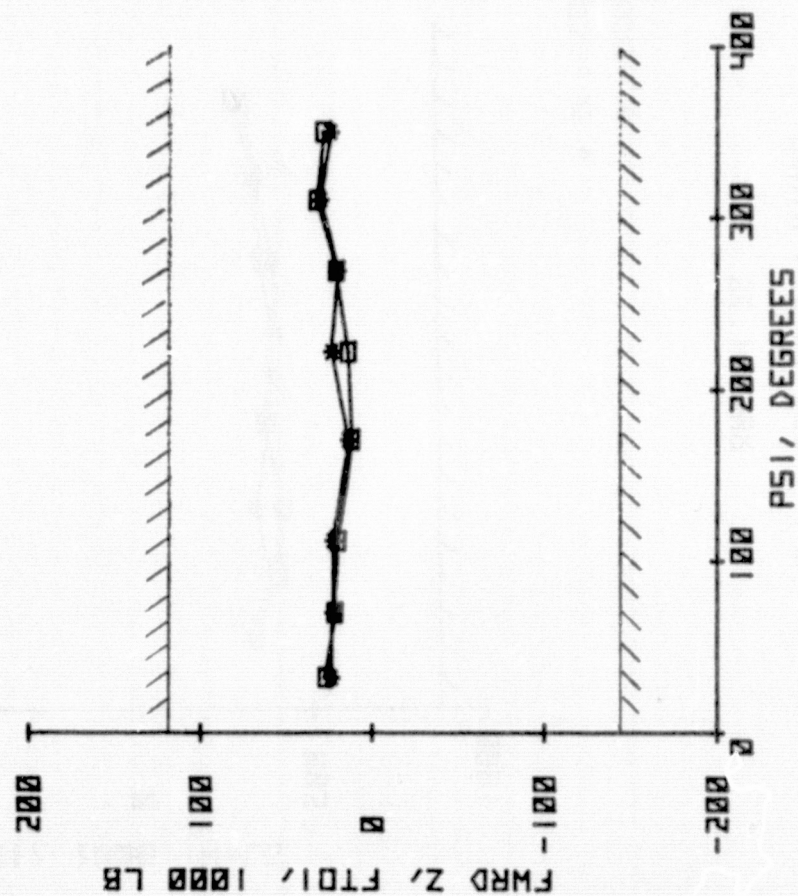


FIGURE A-17.- OFT-1 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
* 50 PERCENTILE

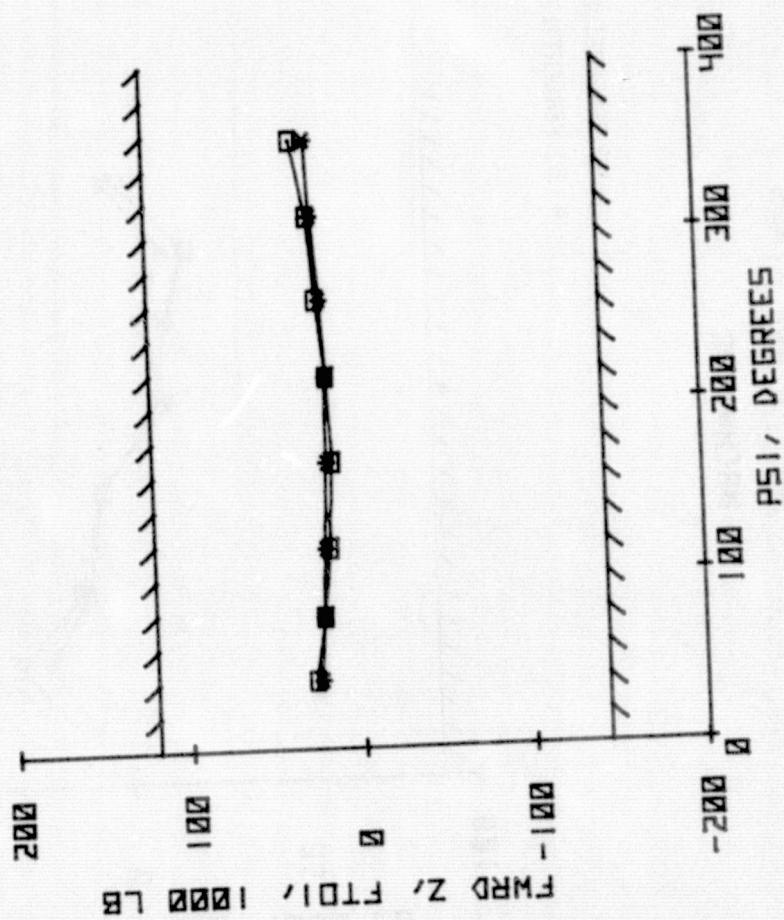


FIGURE A-18.- OFT-I 95% VS 50% WINDS

MACH=1.05

□ 95 PERCENTILE
• 50 PERCENTILE

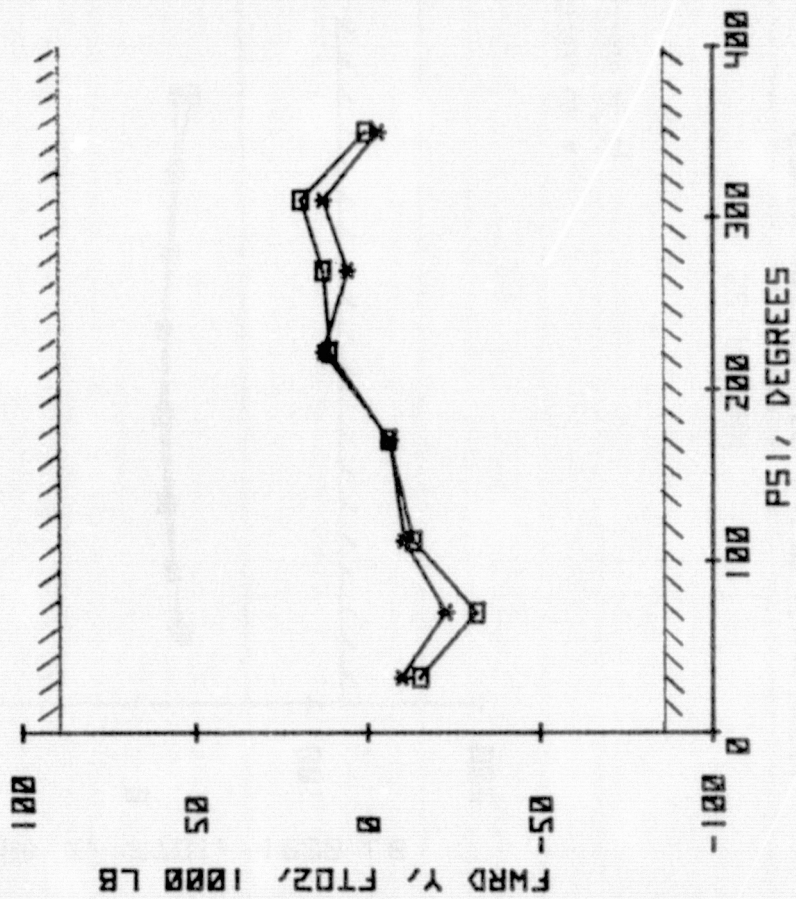


FIGURE A-19.- OFT-I 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
* 50 PERCENTILE

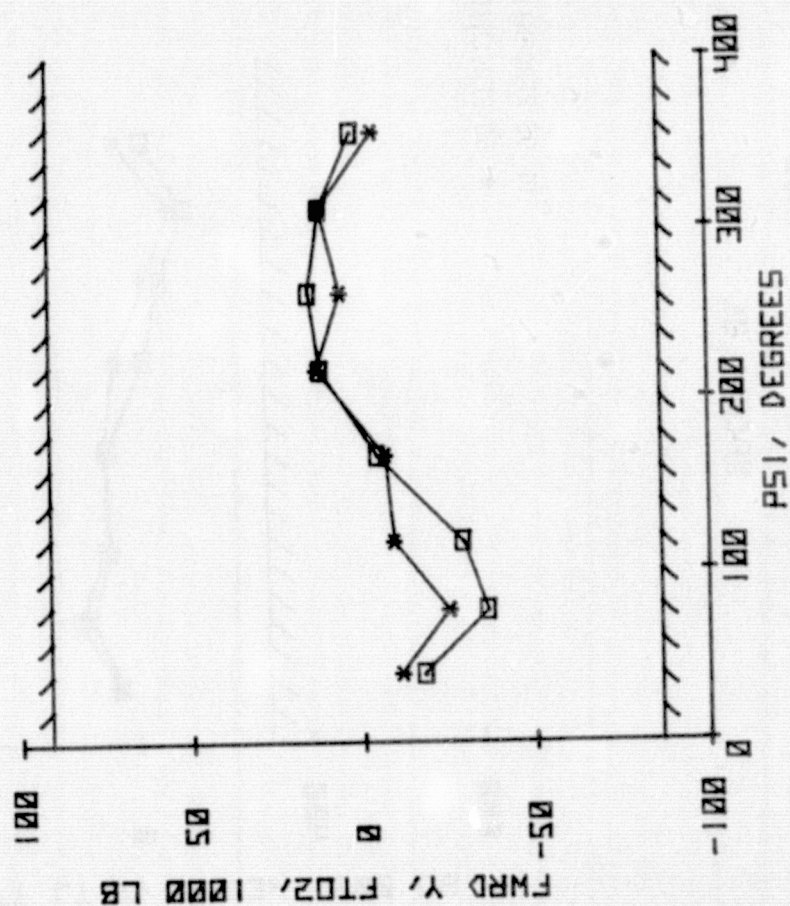


FIGURE A-20.- DFT-1 95% VS 50% WINDS

MACH=1.05

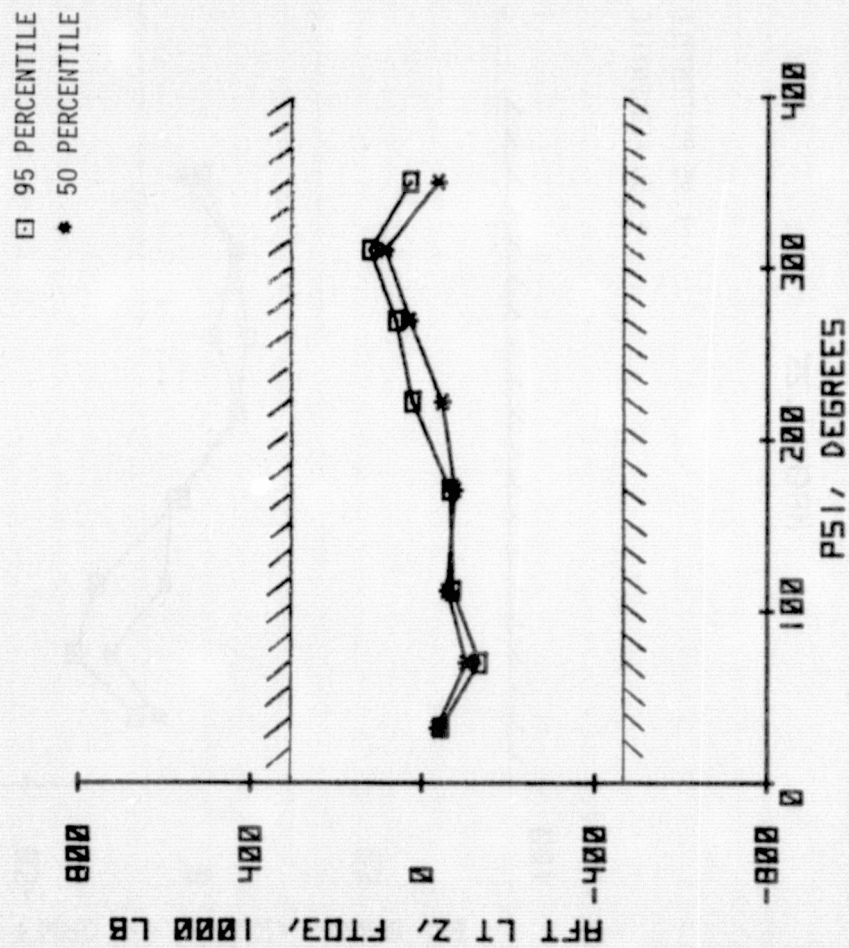


FIGURE 21.- OFT-1 95% VS 50% WINDS

MACH=1.25

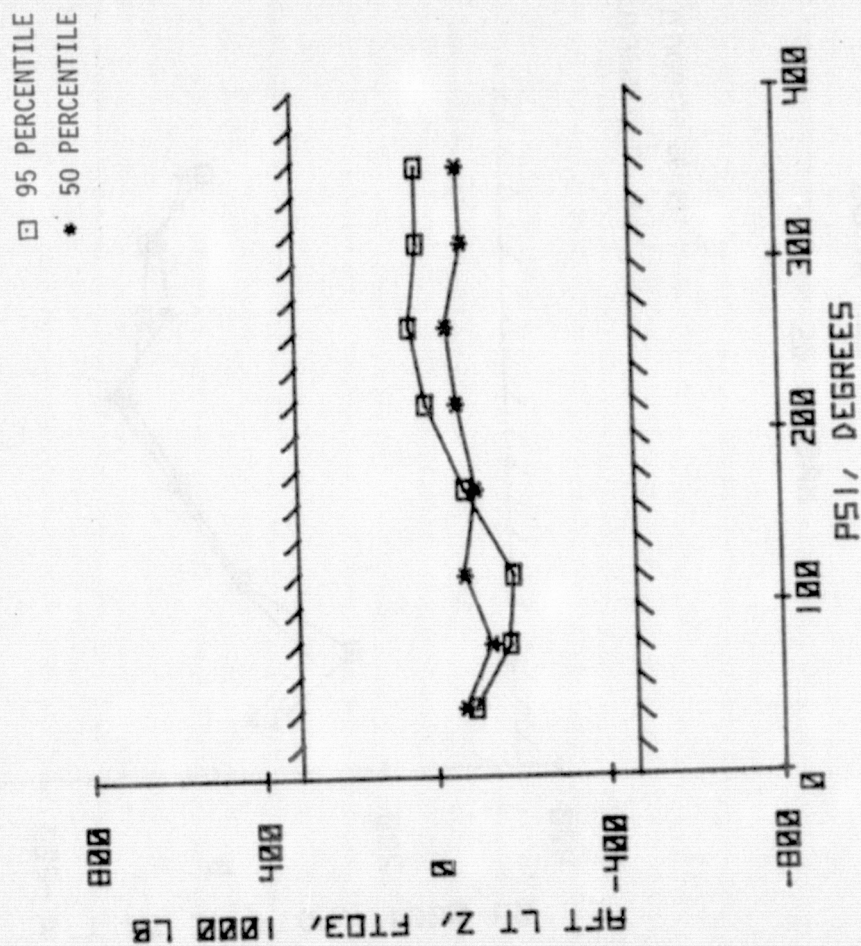


FIGURE A-22.- DFT-1 95% VS 50% WINDS

MACH=1.05

□ 95 PERCENTILE
* 50 PERCENTILE

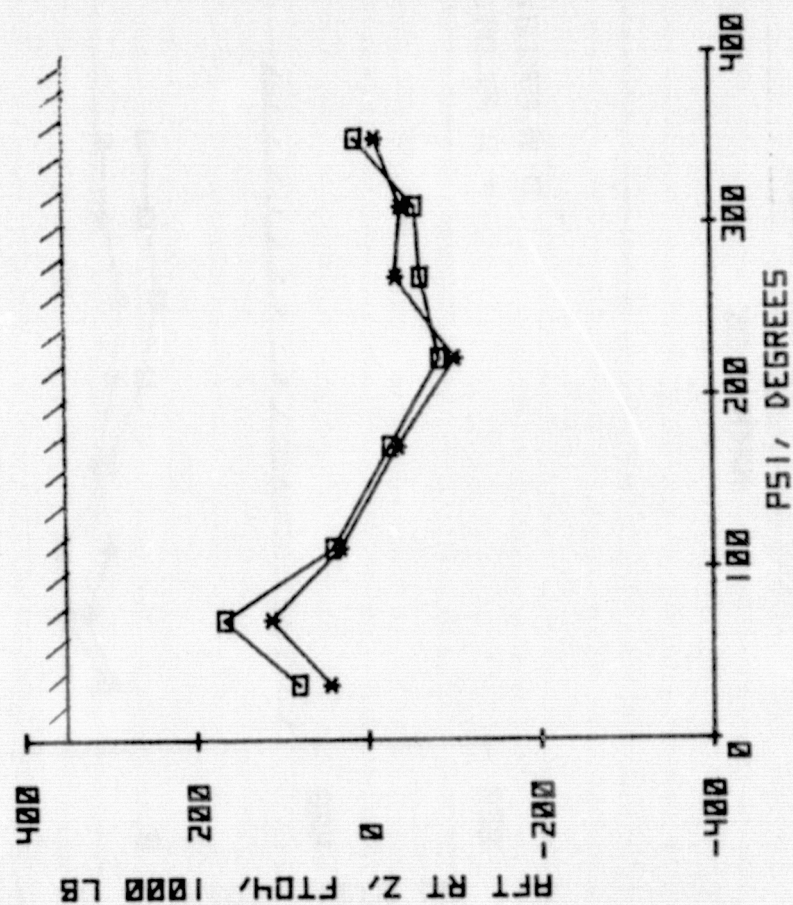


FIGURE A-23.- OFT-I 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
* 50 PERCENTILE

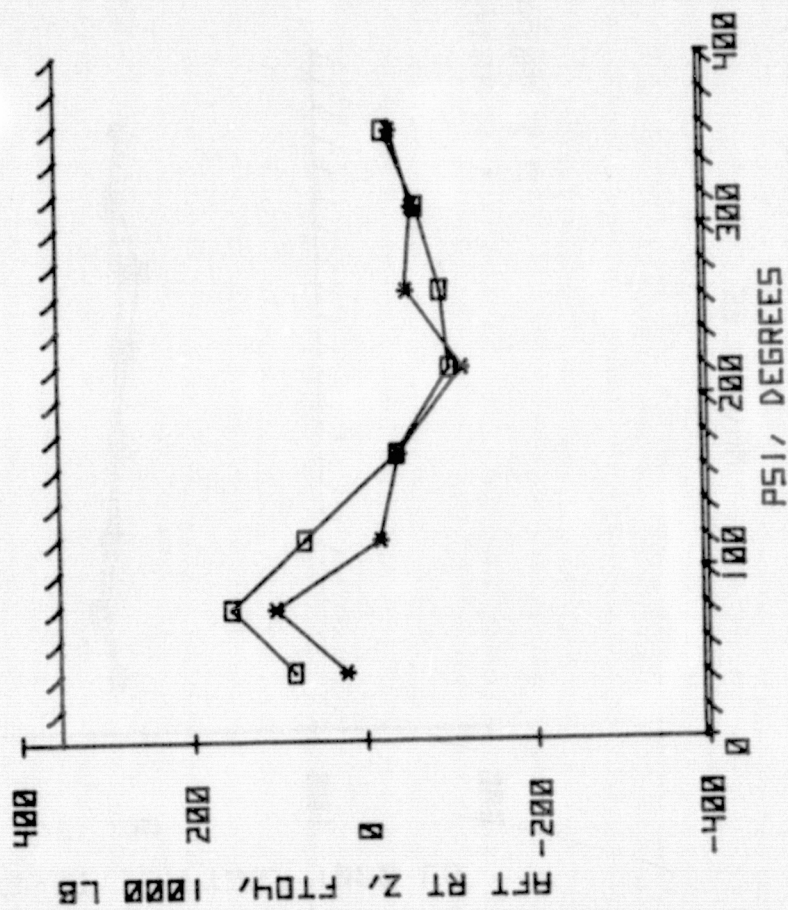


FIGURE A-24.- DFT-1 95% VS 50% WINDS

MACH=1.05

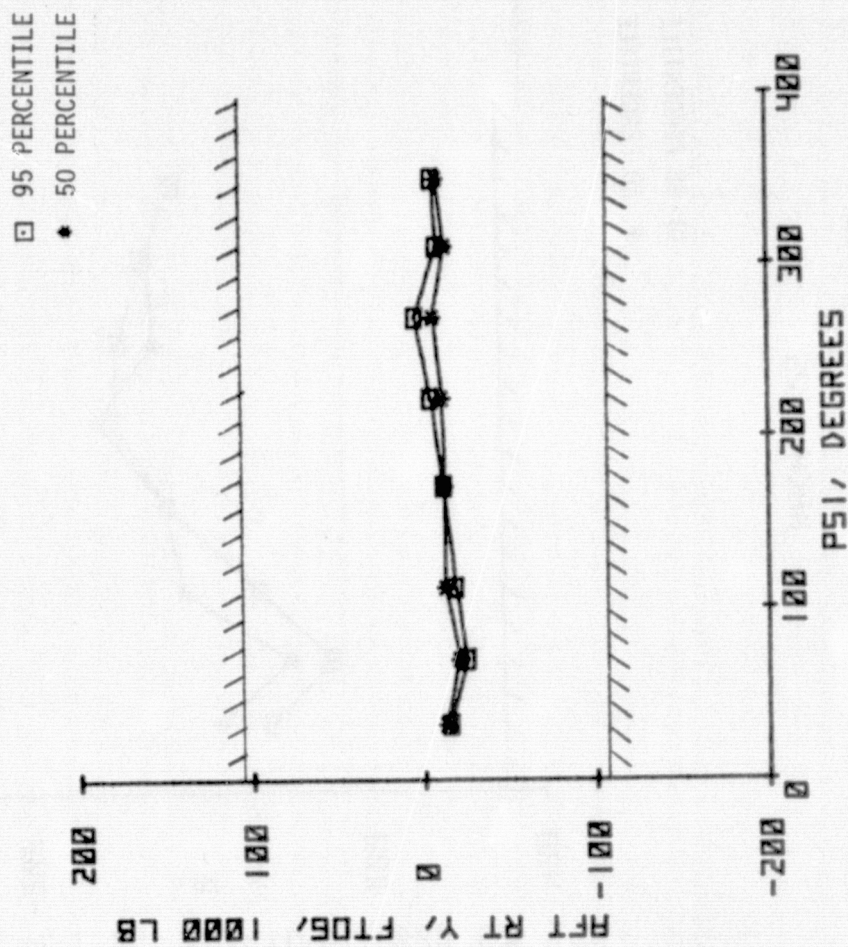


FIGURE A-25.- DFT-1 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
• 50 PERCENTILE

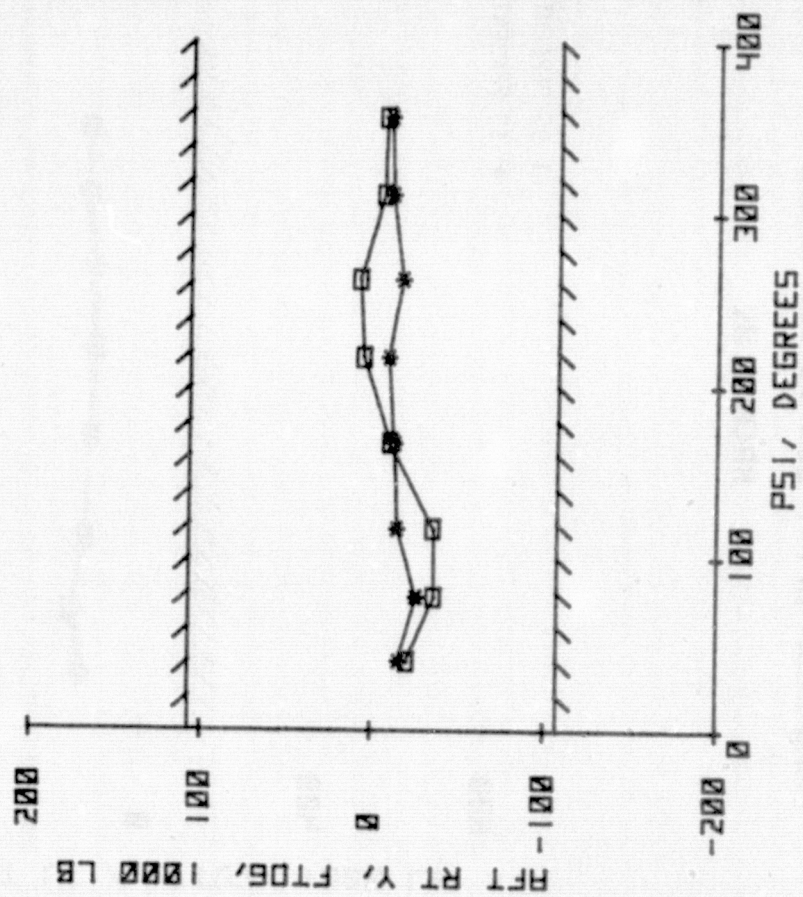


FIGURE A-26.- DFT-1 95% VS 50% WINDS

MACH=1.05

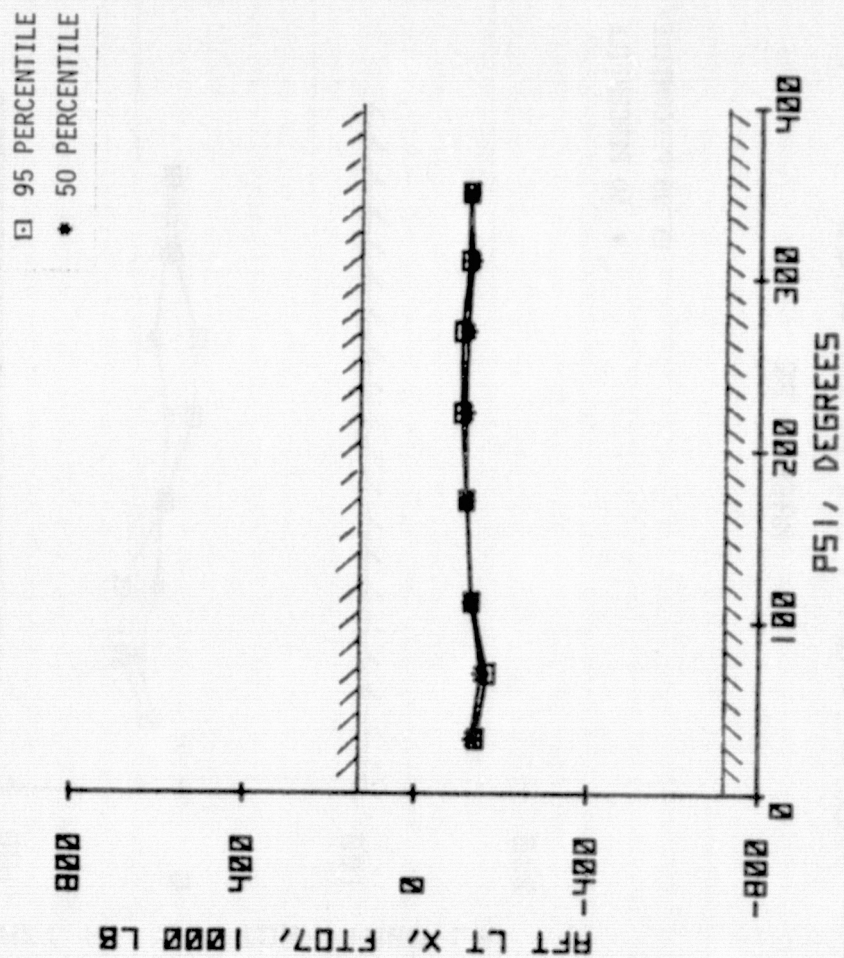


FIGURE A-27.- OFT-1 95% VS 50% WINDS

MACH=1.25

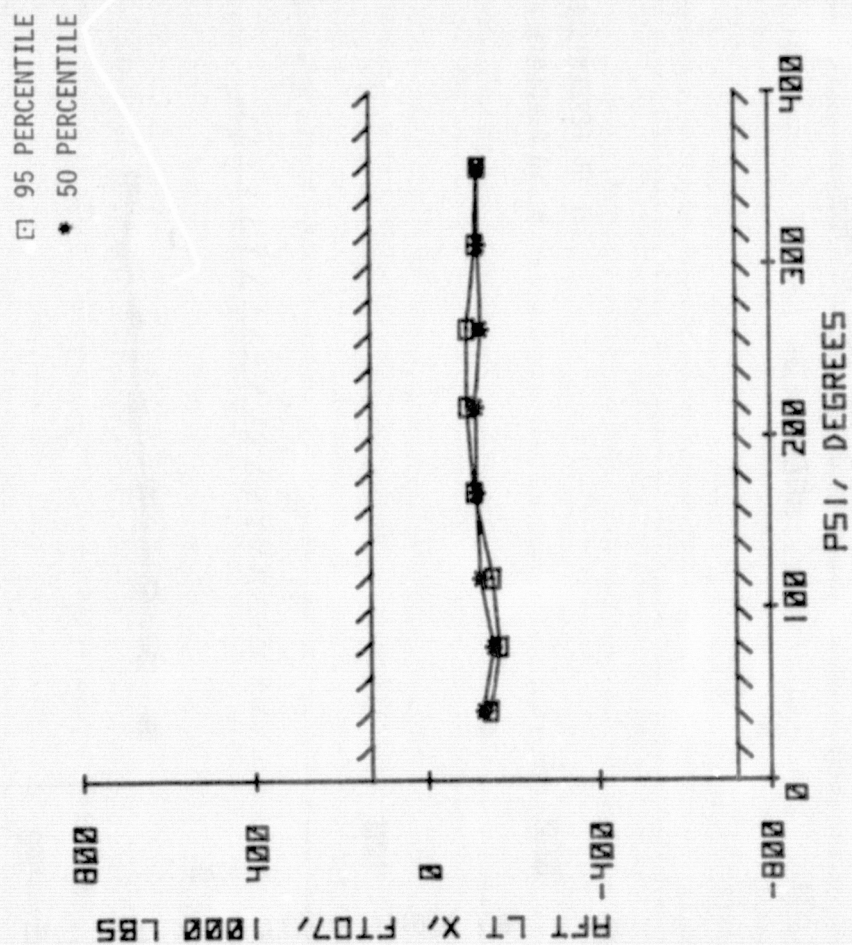


FIGURE 28.- DFT-1 95% VS 50% WINDS

MACH=1.05

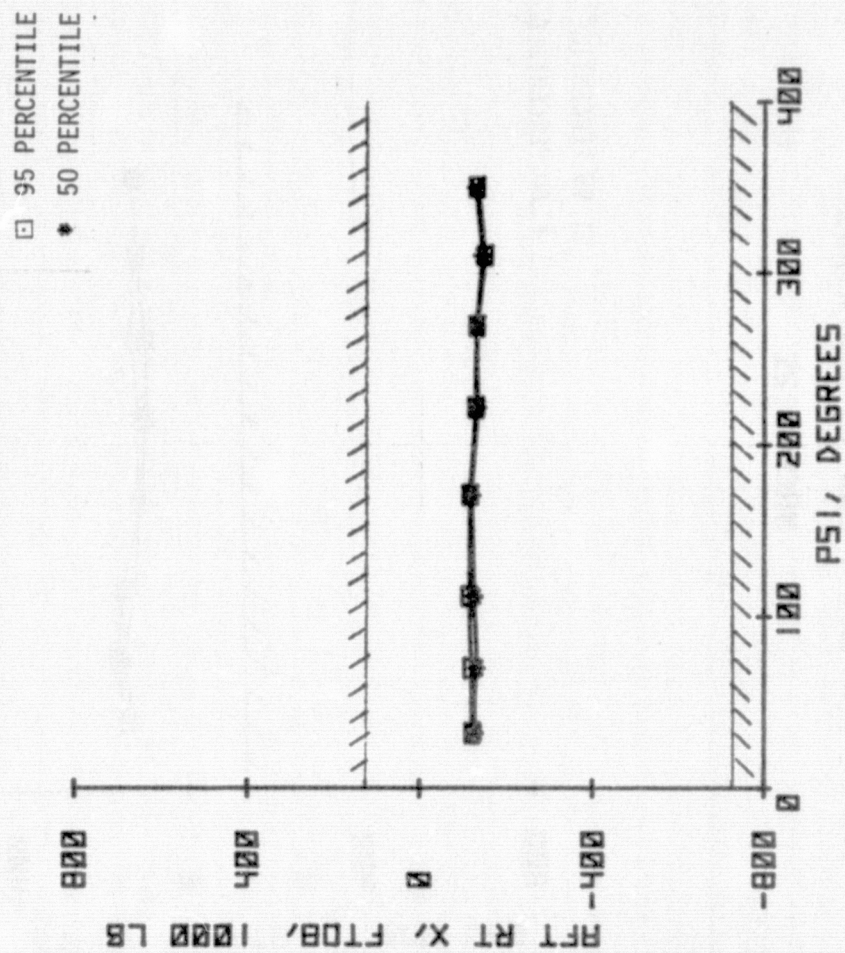


FIGURE A-29.- DFT-I 95% VS 50% WINDS

MACH=1.25

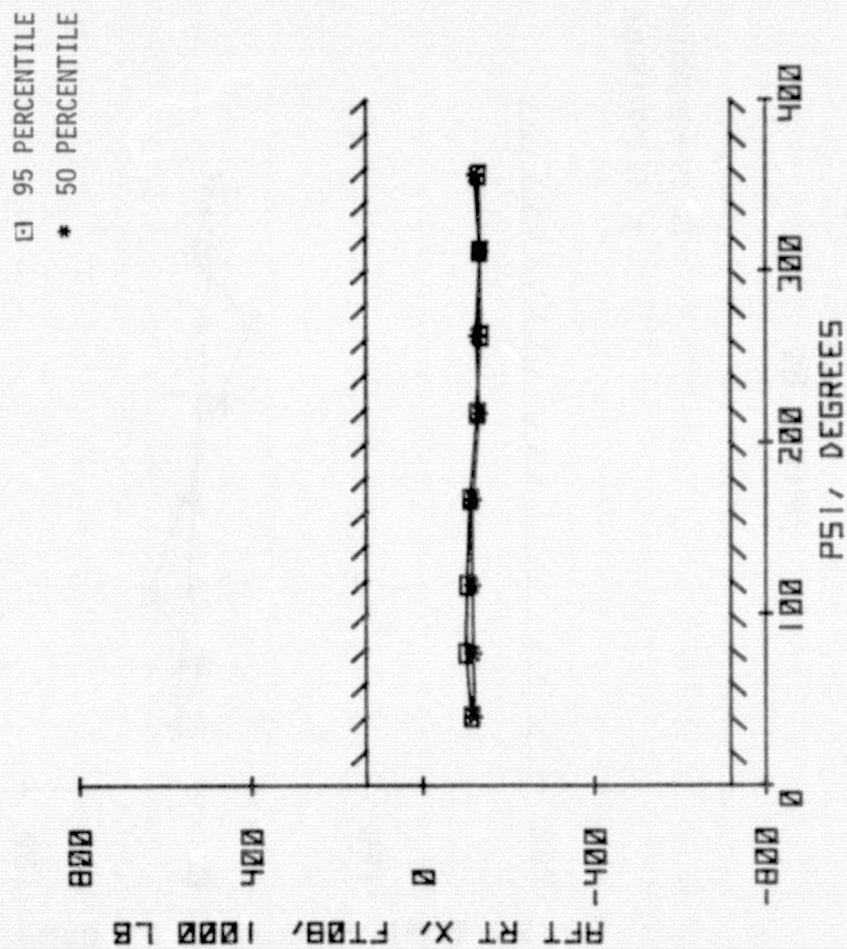


FIGURE A-30.- OFT-1 95% VS 50% WINDS

MACH=1.05

□ 95 PERCENTILE
• 50 PERCENTILE

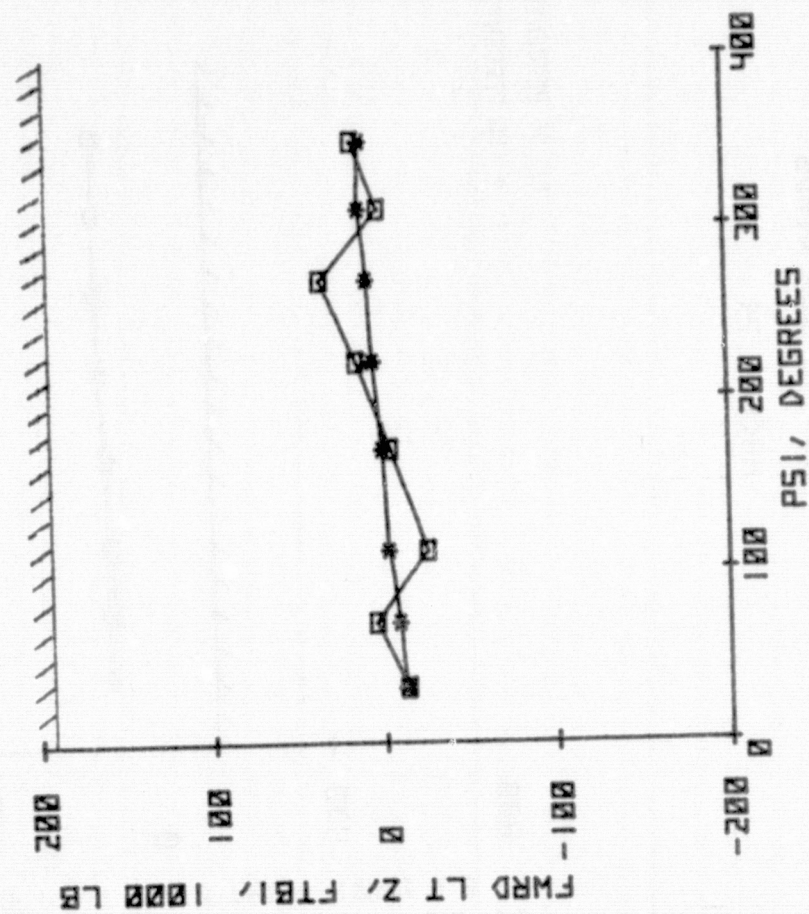


FIGURE A-31.- DFT-1 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
* 50 PERCENTILE

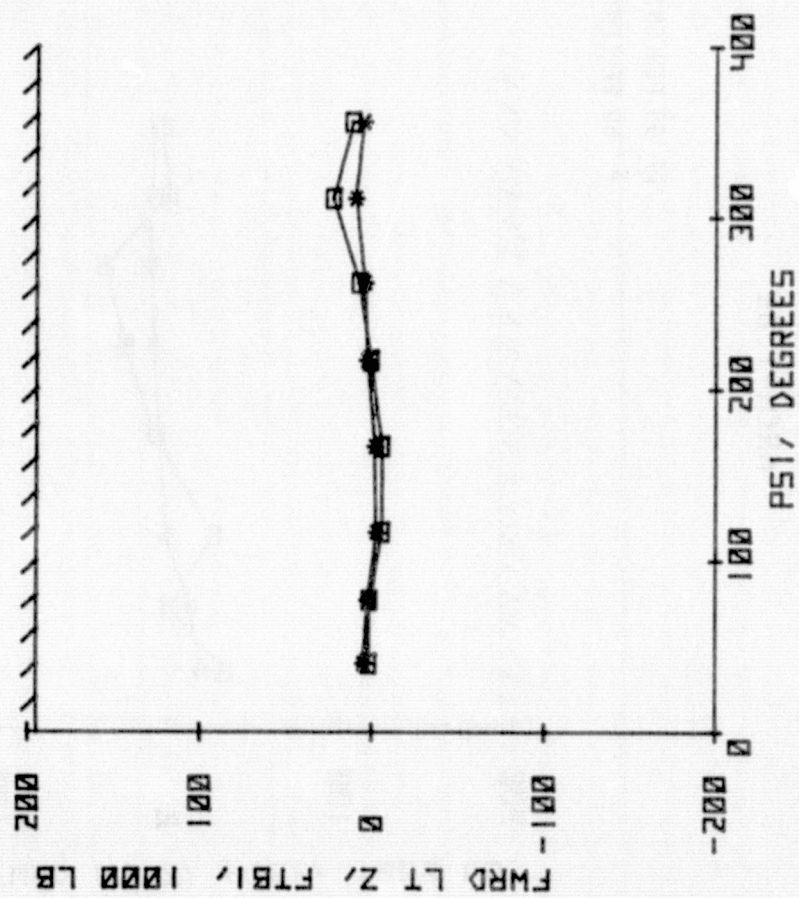


FIGURE A-32.- OFT-1 95% VS 50% WINDS

MACH=1.05

□ 95 PERCENTILE
* 50 PERCENTILE

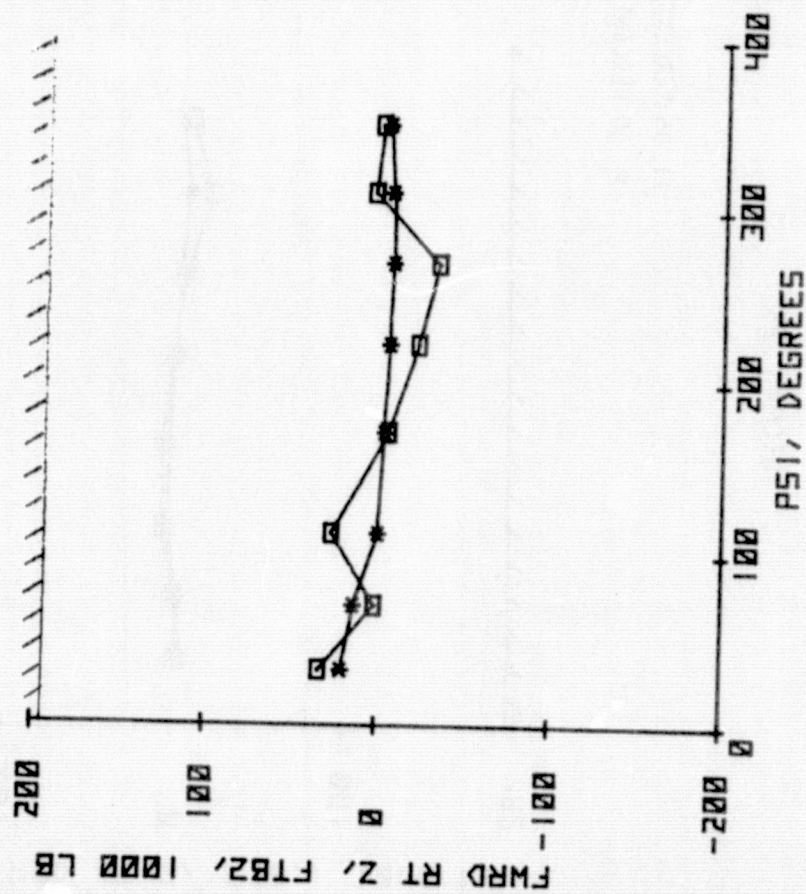


FIGURE A-33.- DFT-1 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
* 50 PERCENTILE

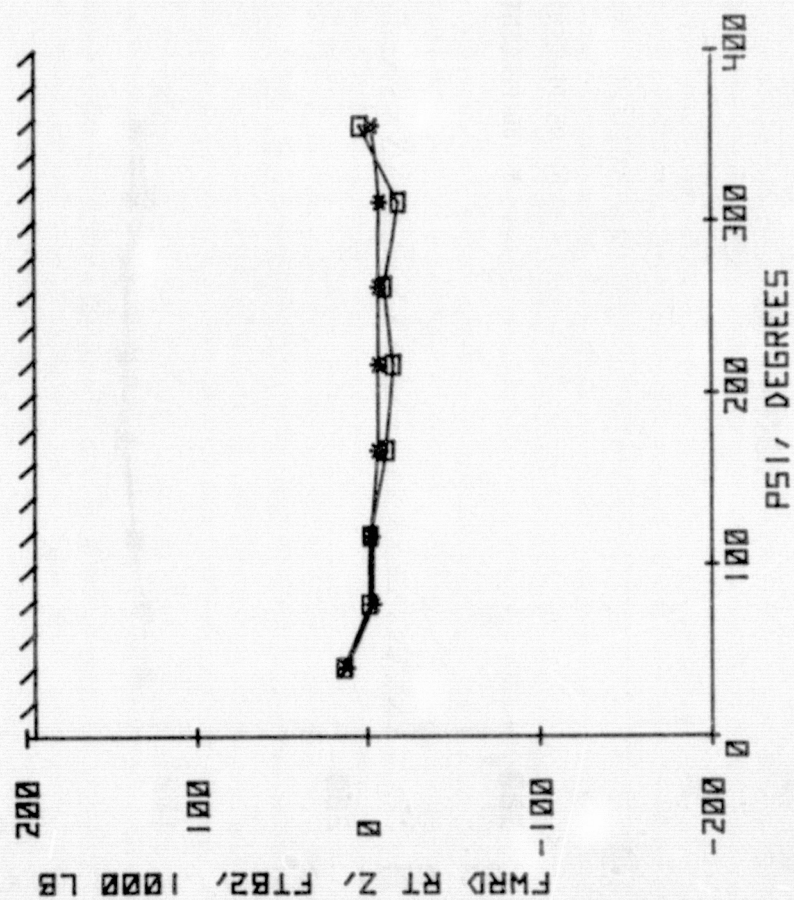


FIGURE A-34.- DFT-1 95% VS 50% WINDS

MACH=1.05

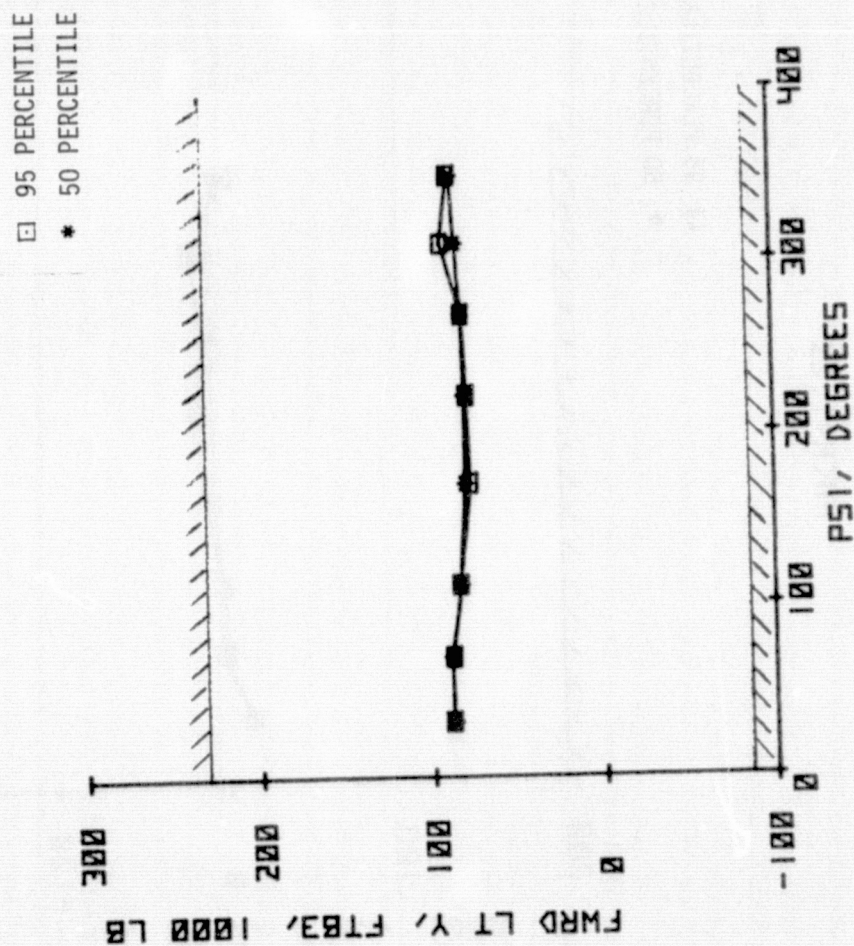


FIGURE A-35.- OFT-1 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
• 50 PERCENTILE

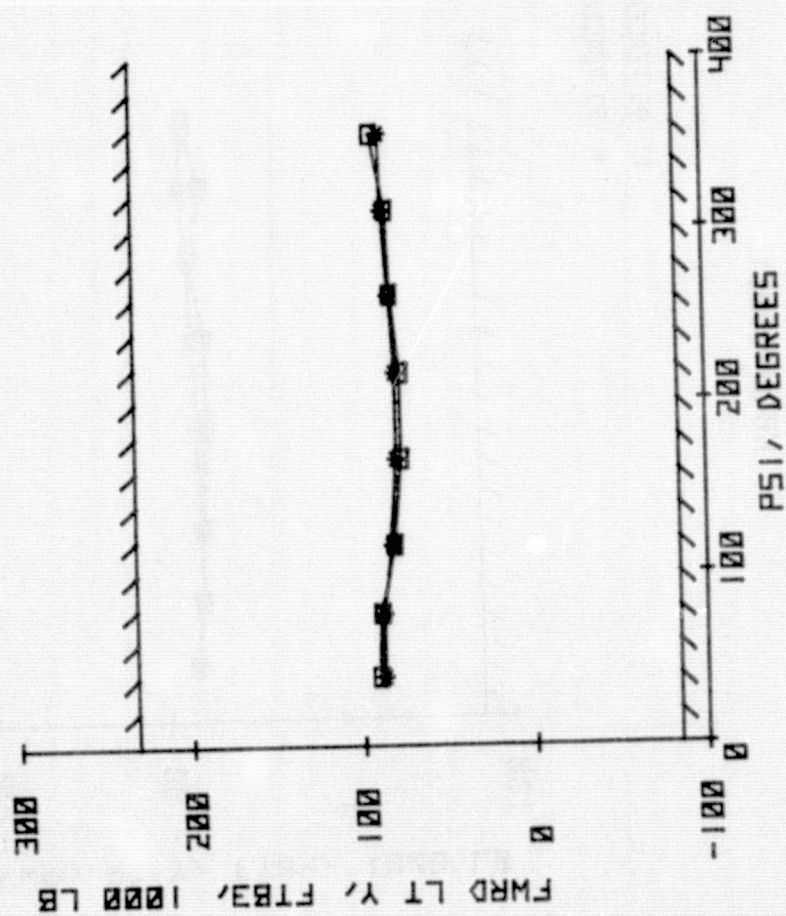


FIGURE A-36.- DFT-1 95% VS 50% WINDS

MACH=1.05

□ 95 PERCENTILE
● 50 PERCENTILE

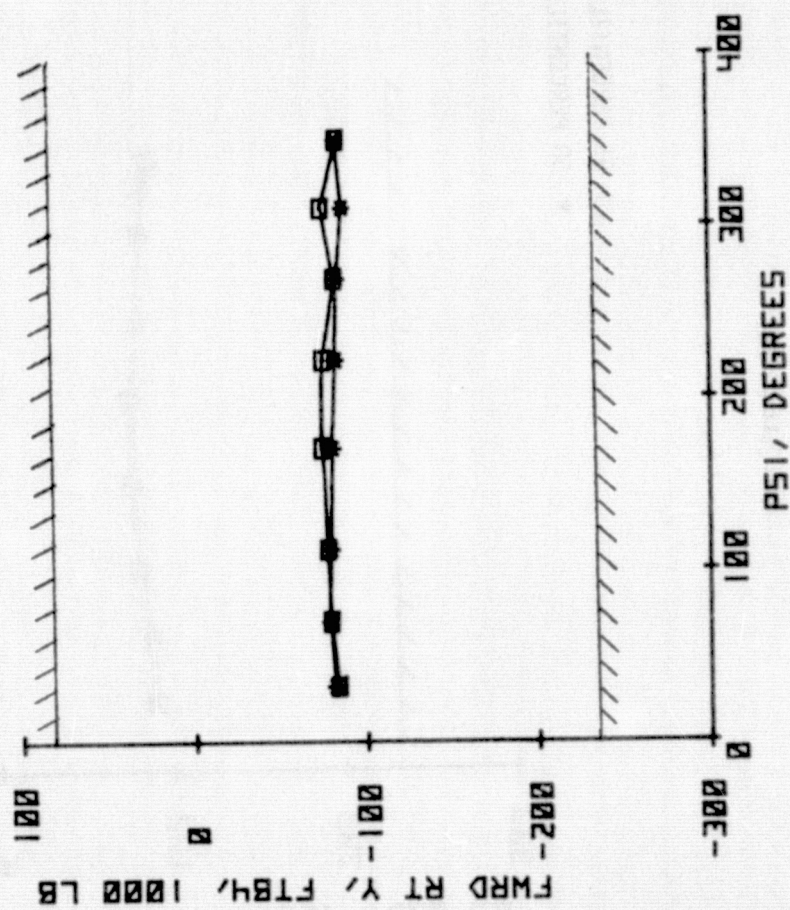


FIGURE A-37.- OFT-1 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
• 50 PERCENTILE

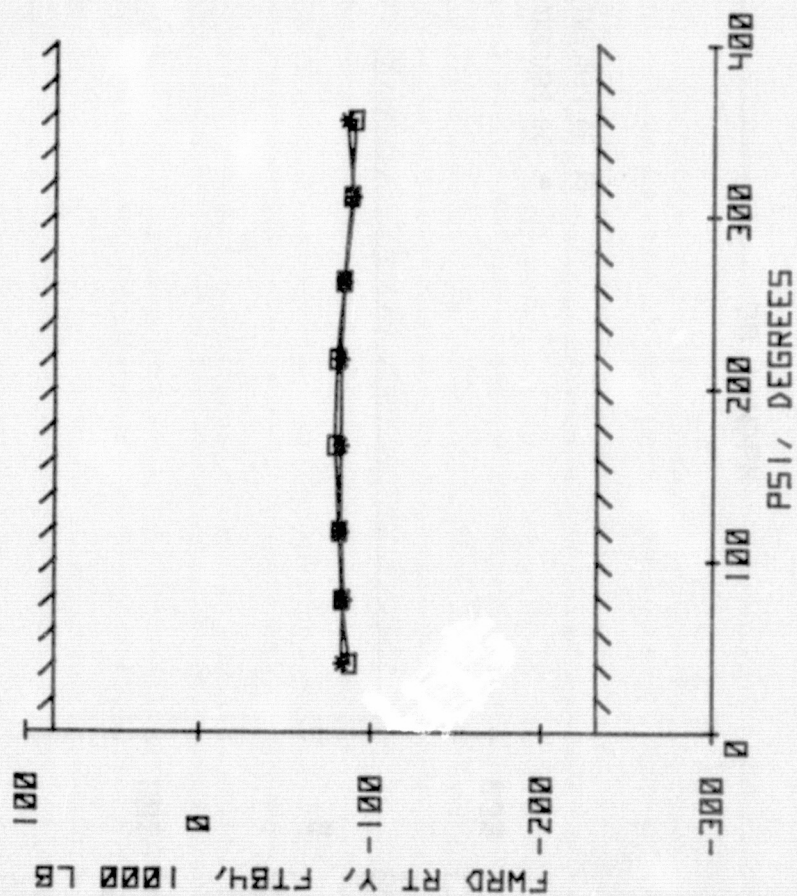


FIGURE A-38.- DFT-1 95% VS 50% WINDS

MACH=1.05

□ 95 PERCENTILE
• 50 PERCENTILE

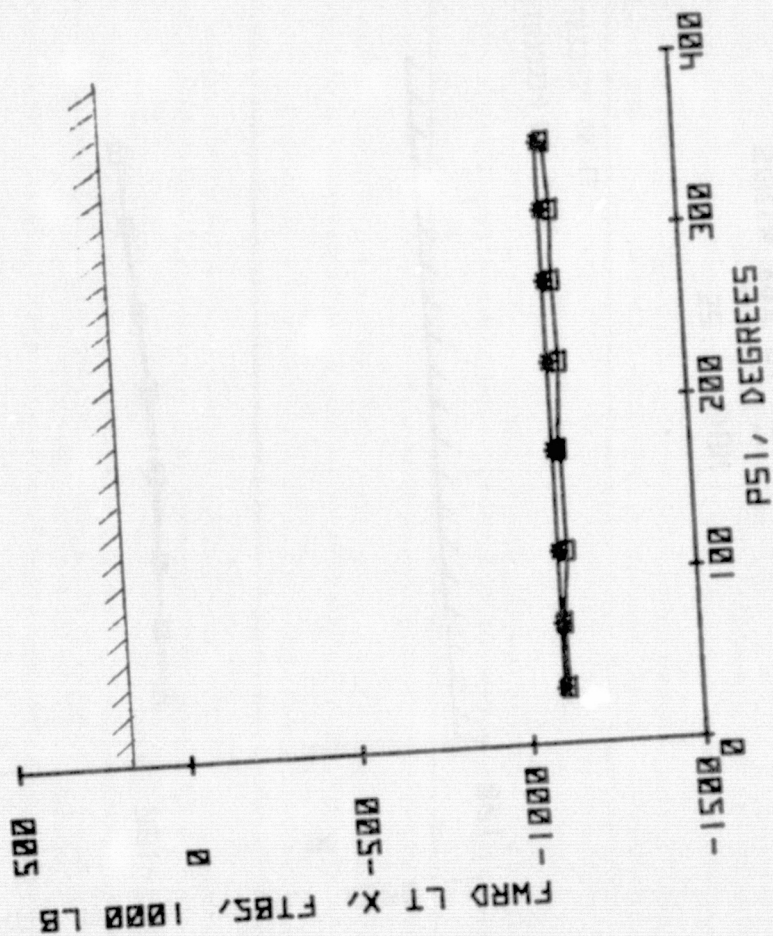


FIGURE A-39.- OFT-1 95% VS 50% WINDS

MACH=1.25

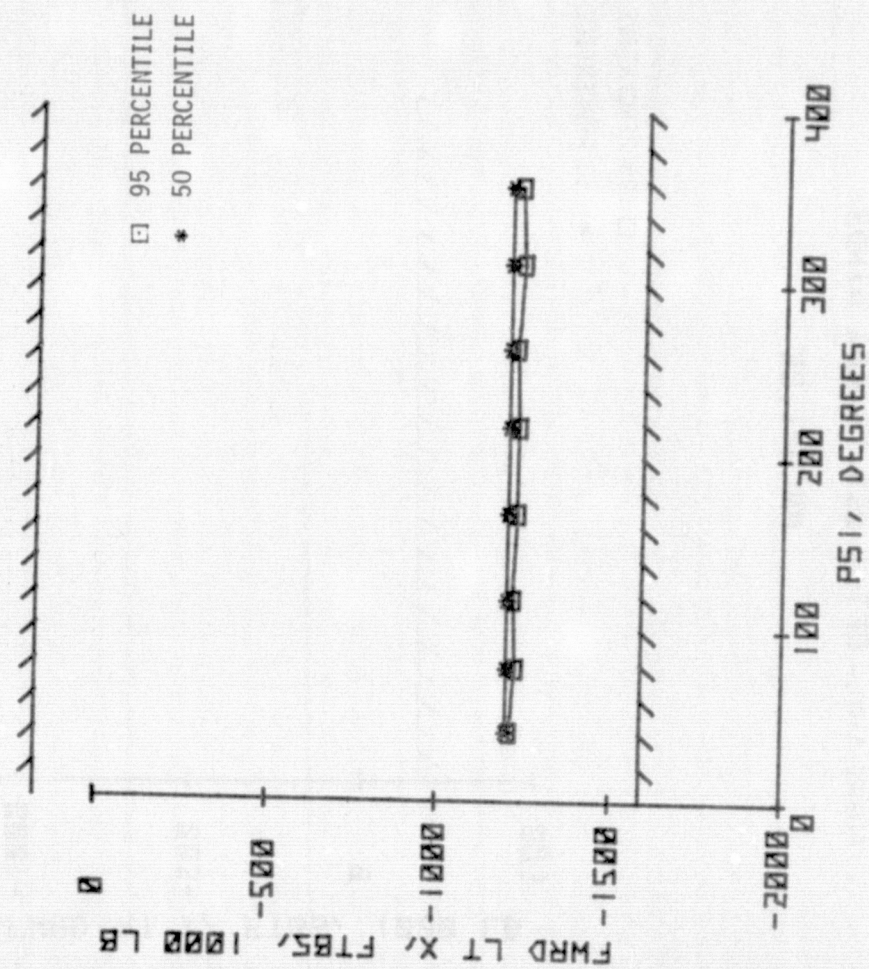


FIGURE A-40.- OFT-1 95% VS 50% WINDS

MACH=1.05

□ 95 PERCENTILE
• 50 PERCENTILE

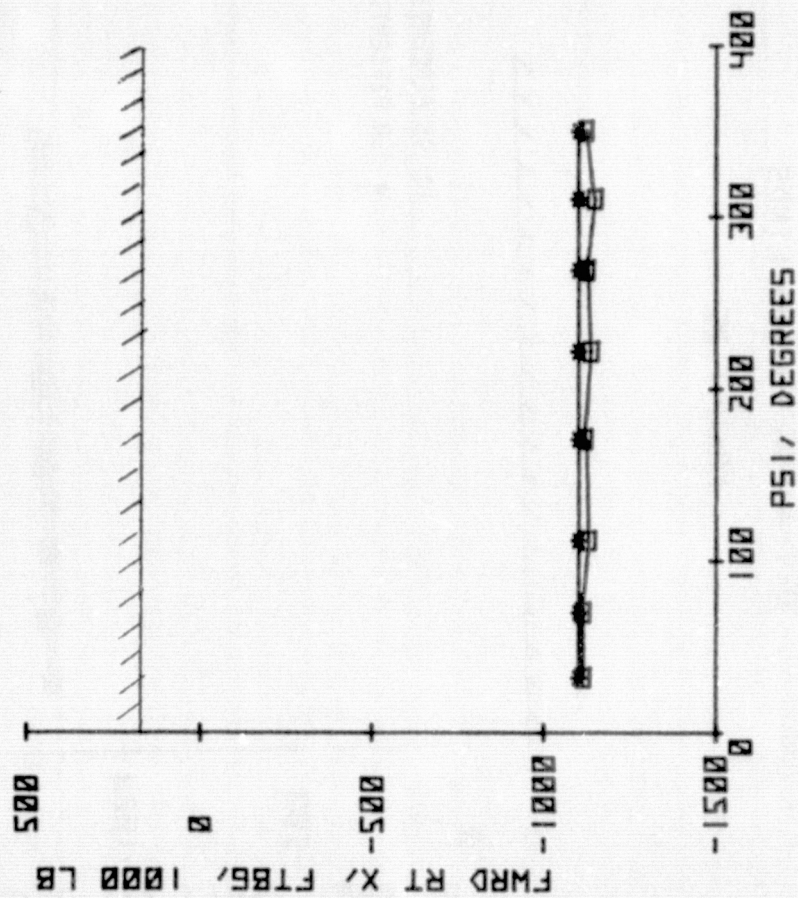


FIGURE A-41.- DFT-1 95% VS 50% WINDS

MRCH=1.25

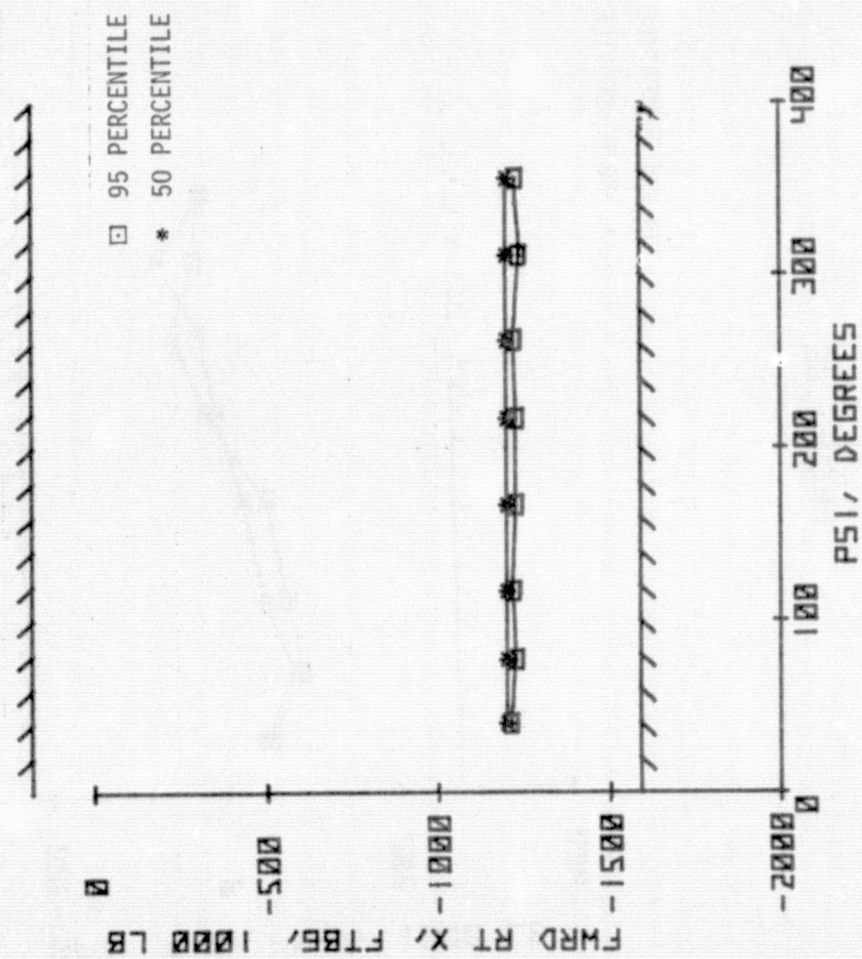


FIGURE A-42.- OFT-1 95% VS 50% WINDS

MACH=1.05

□ 95 PERCENTILE

* 50 PERCENTILE

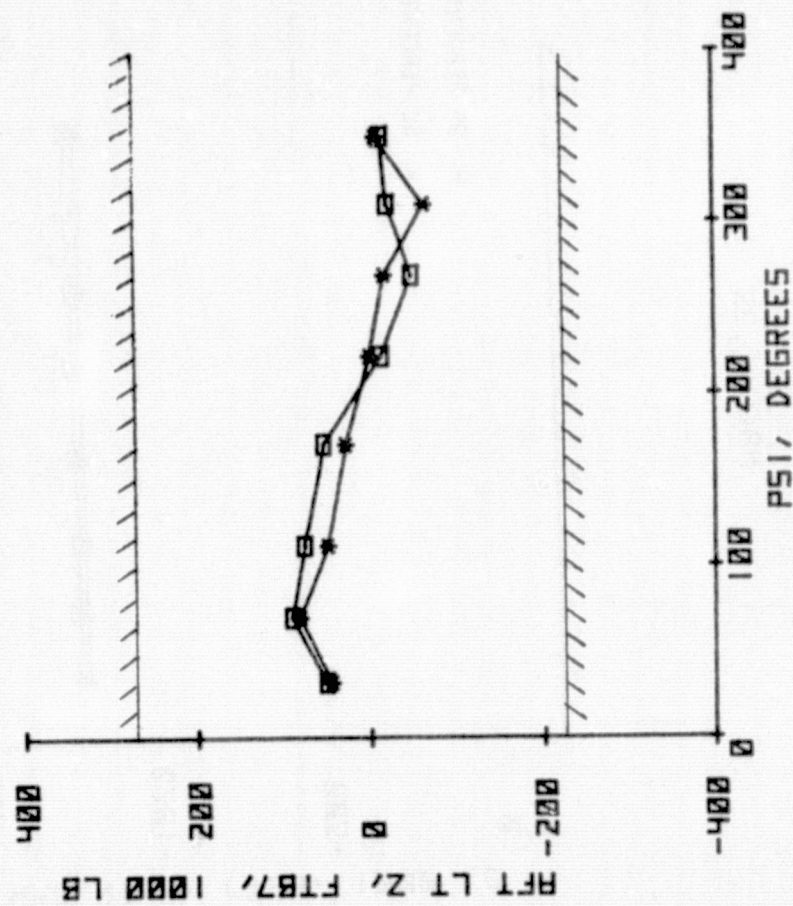


FIGURE A-43.- OFT-I 95% VS 50% WINDS

MRCH=i.25

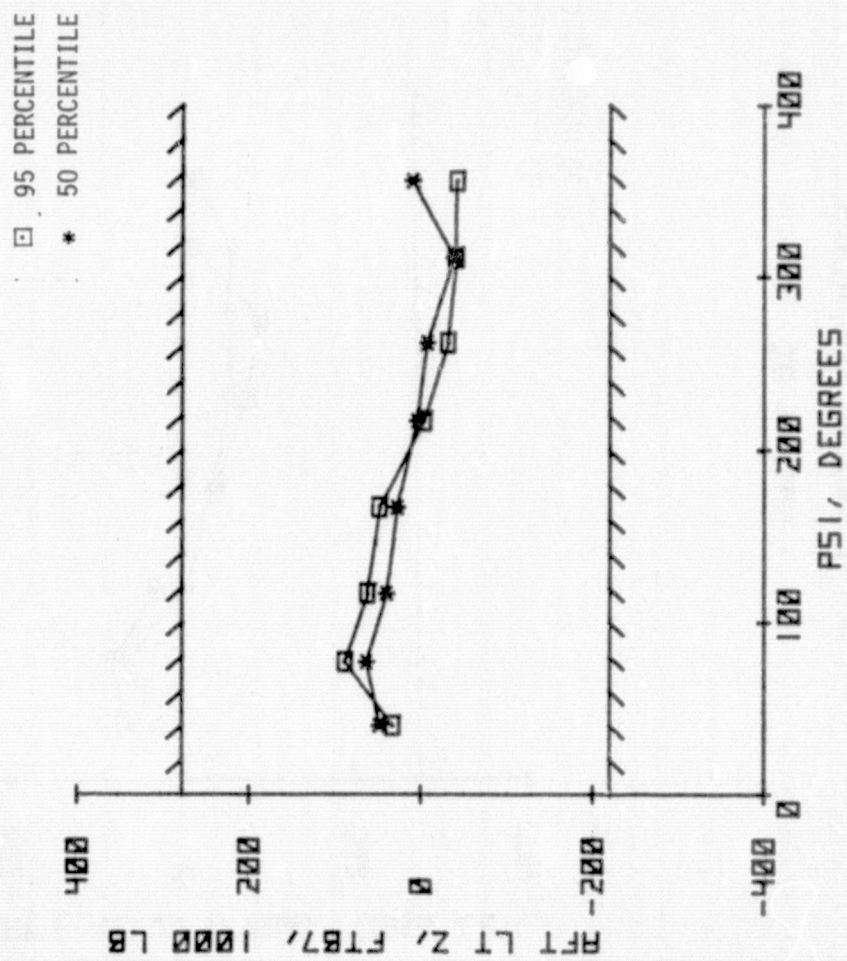


FIGURE A-44.- DFT-1 95% VS 50% WINDS

MACH=1.05

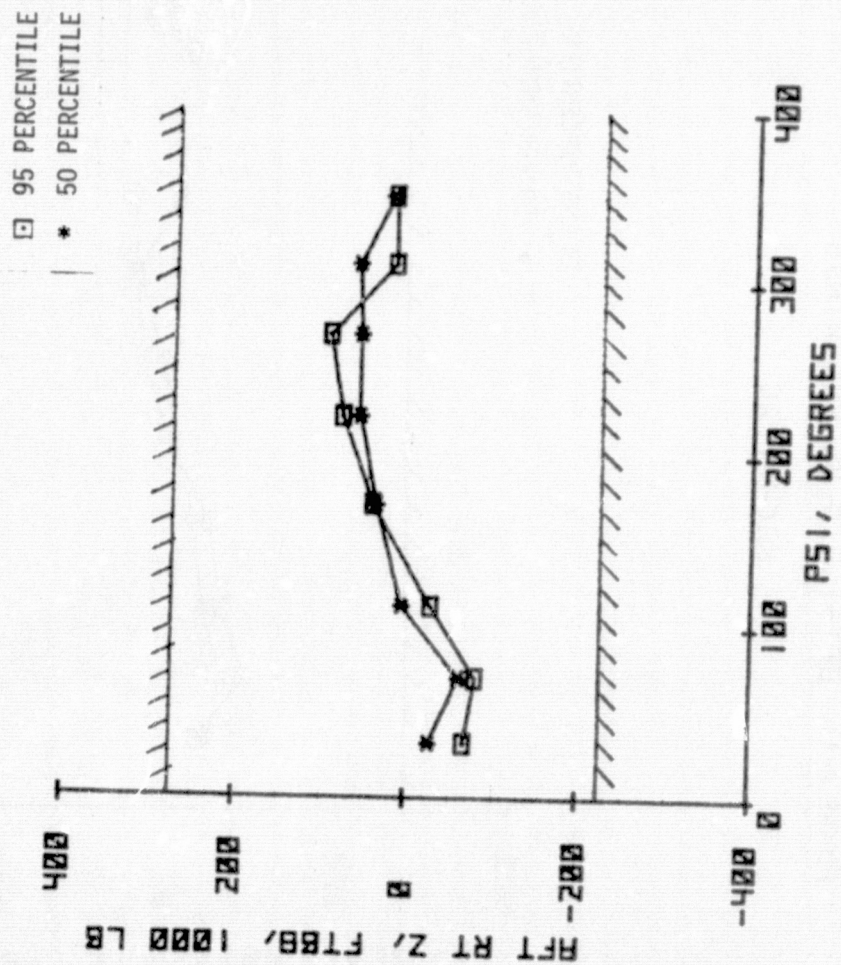


FIGURE A-45.- DFT-1 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
* 50 PERCENTILE

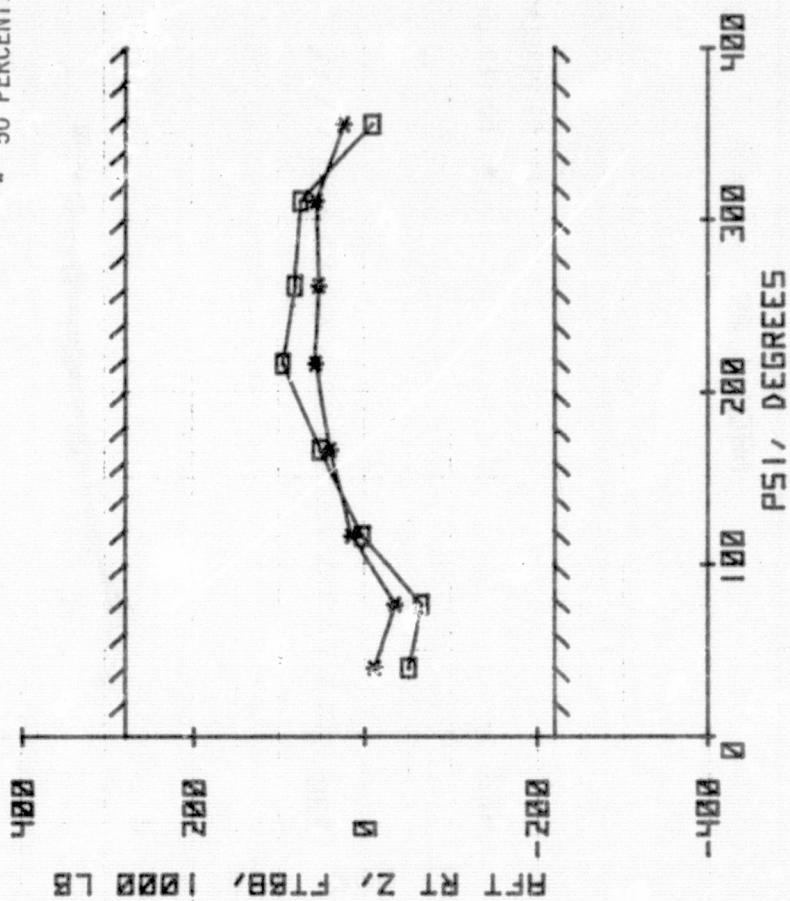


FIGURE A-46.- DFT-1 95% VS 50% WINDS

MACH=1.05

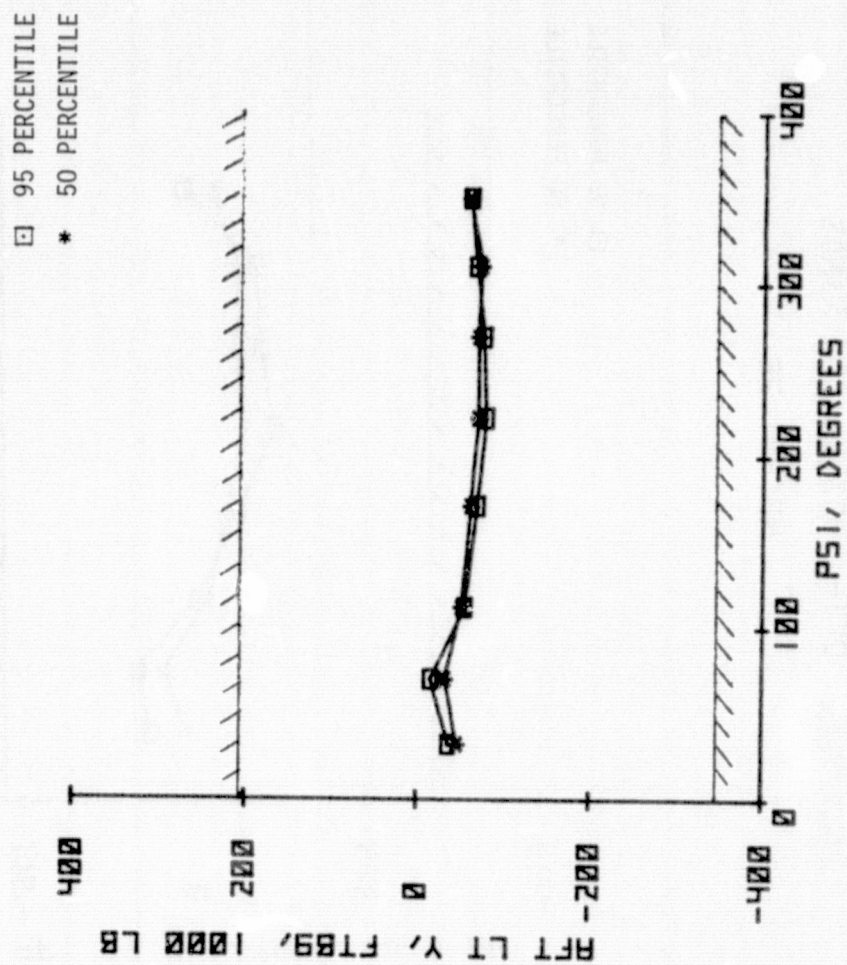


FIGURE A-47.- DFT-1 95% VS 50% WINDS

MACH=1.25

□ 95 PERCENTILE
* 50 PERCENTILE

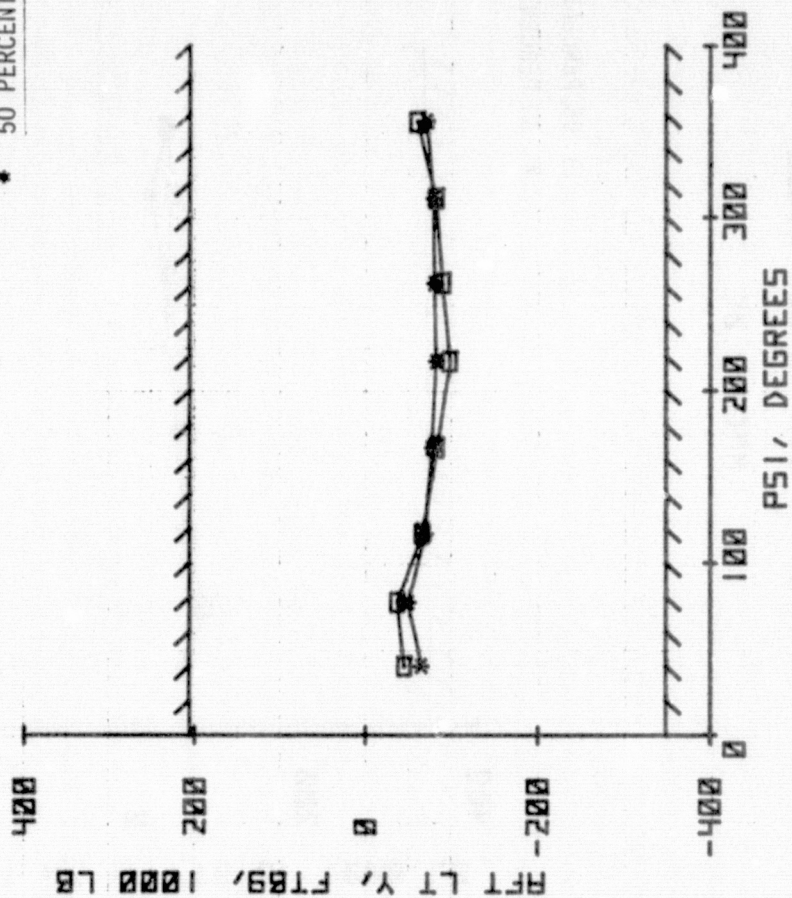


FIGURE A-48.- DFT-1 95% VS 50% WINDS

MACH=1.05

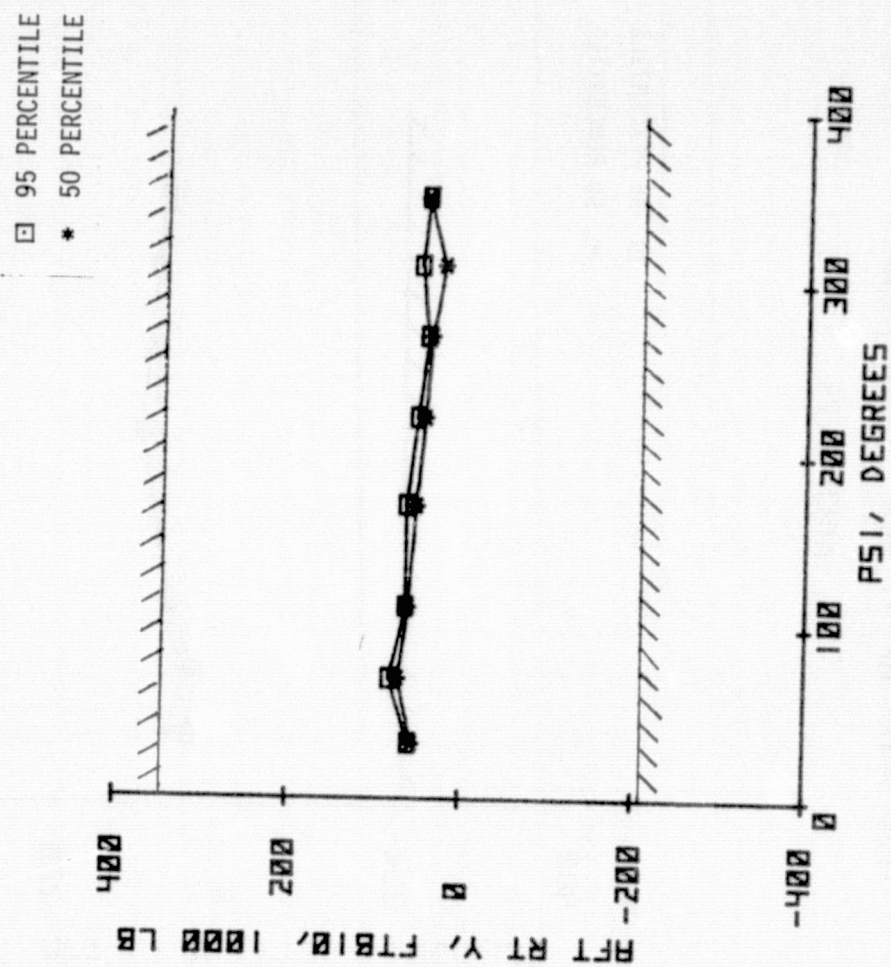


FIGURE A-49.- OFT-1 95% VS 50% WINDS

MACH=1.25

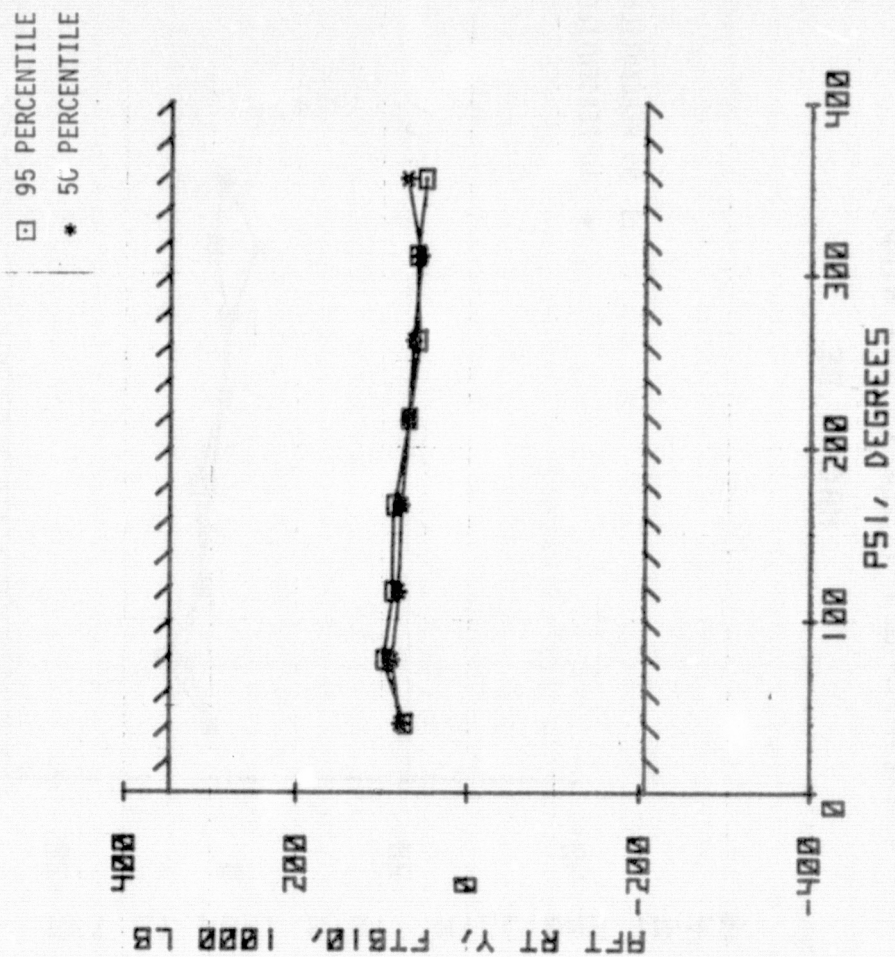


FIGURE A-50.- OFT-1 95% VS 50% WINDS

MACH=1.05

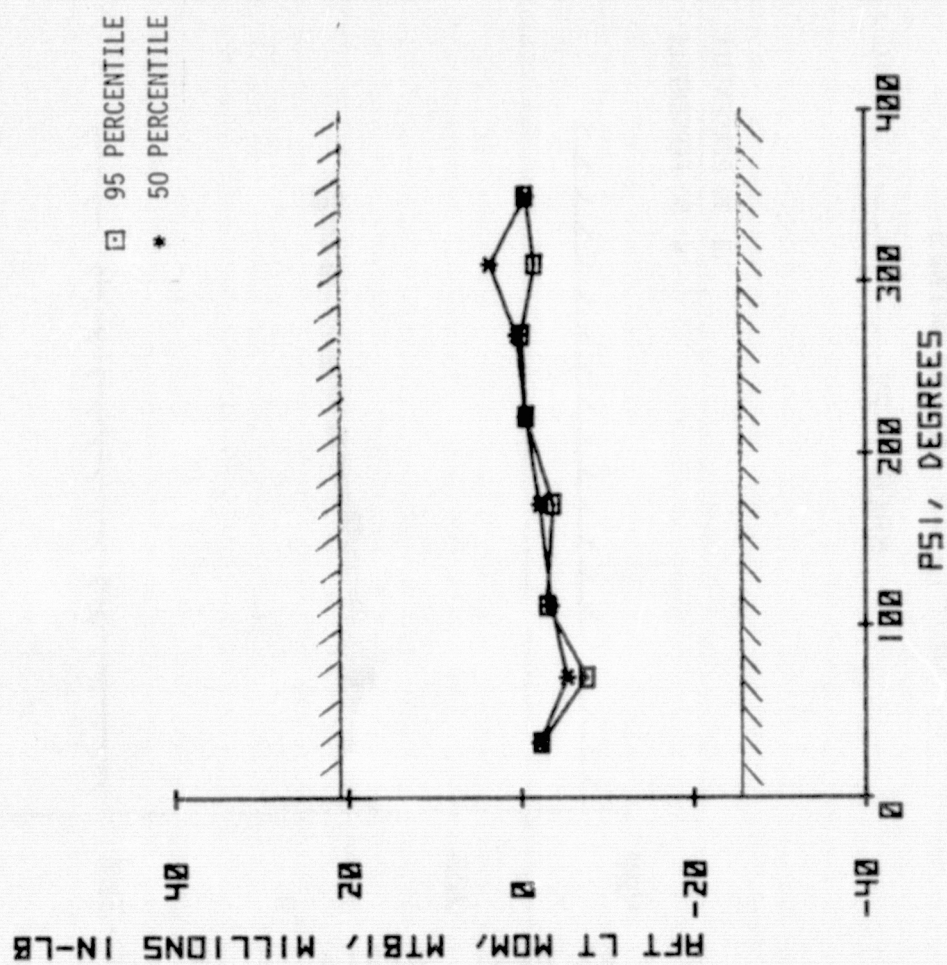


FIGURE A-51.- DFT-1 95% VS 50% WINDS

MRCH=1.25

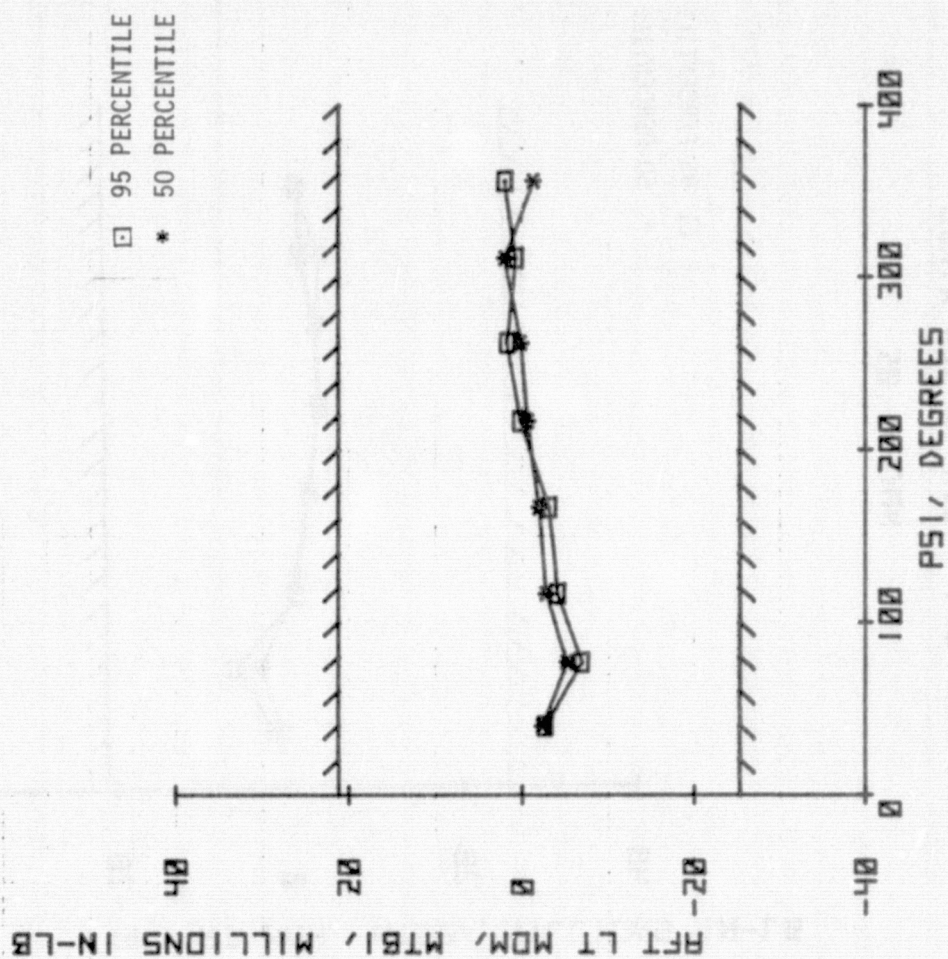


FIGURE A-52.- DFT-1 95% VS 50% WINDS

MACH=1.05

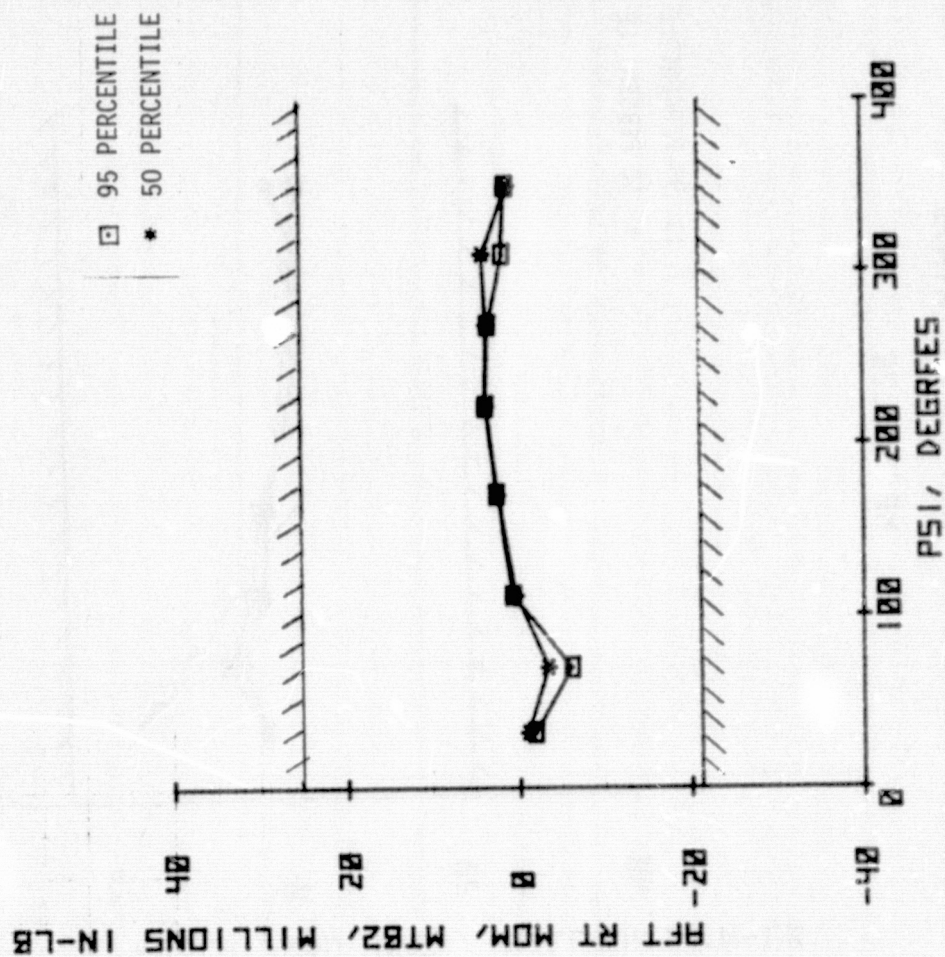


FIGURE A-53.- DFT-1 95% VS 50% WINDS

MACH=1.25

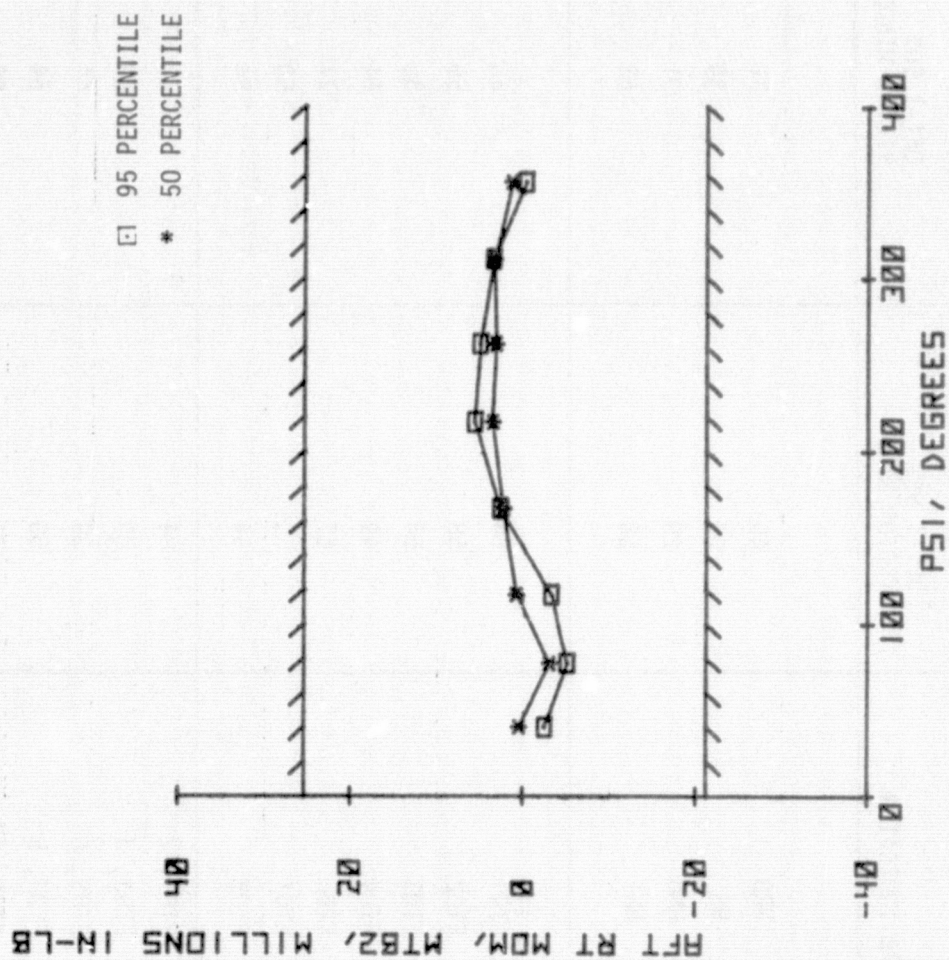


FIGURE A-54 - IMPACT OF WIND CRITERIA, PERCENT MARGIN

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LOAD INDICATOR	OFT-1 95% VECTOR WINDS	OFT-1 50% VECTOR WINDS
WRB	45	51
WS	33	39
HMO	29	31
HMI	58	62
FT01	66	66
FT02	58	69
FT03	54	58
FT04	49	64
FT06	67	77
FT07	50	50
FT08	54	54
FTB1, 2	84	88
FTB3, 4	89	89
FTB5, 6	39	44
FTB7, 8	56	64
FTB9, 10	79	80
MTB1, 2	65	78

Note: $1.05 < \text{Mach No.} < 1.25$

FIGURE A-55.- DFT-1 95% VS 50% WINDS

MACH=1.05

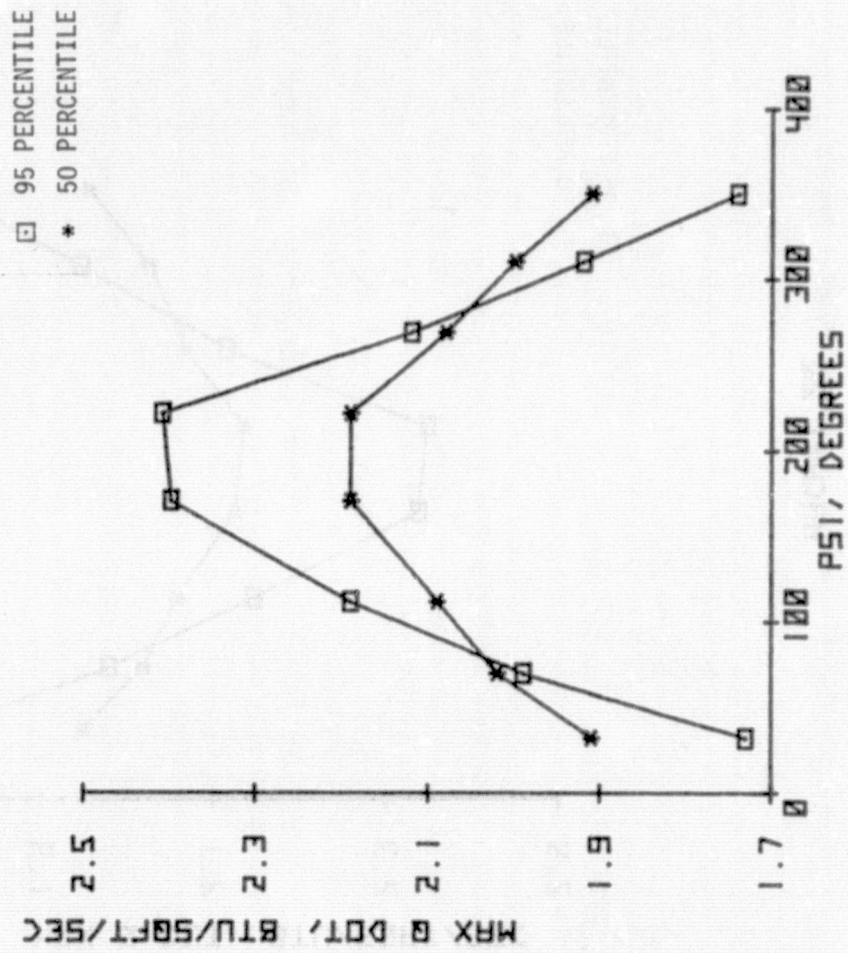


FIGURE A-56.- ODT-1 95% VS 50% WINDS

MACH=1.25

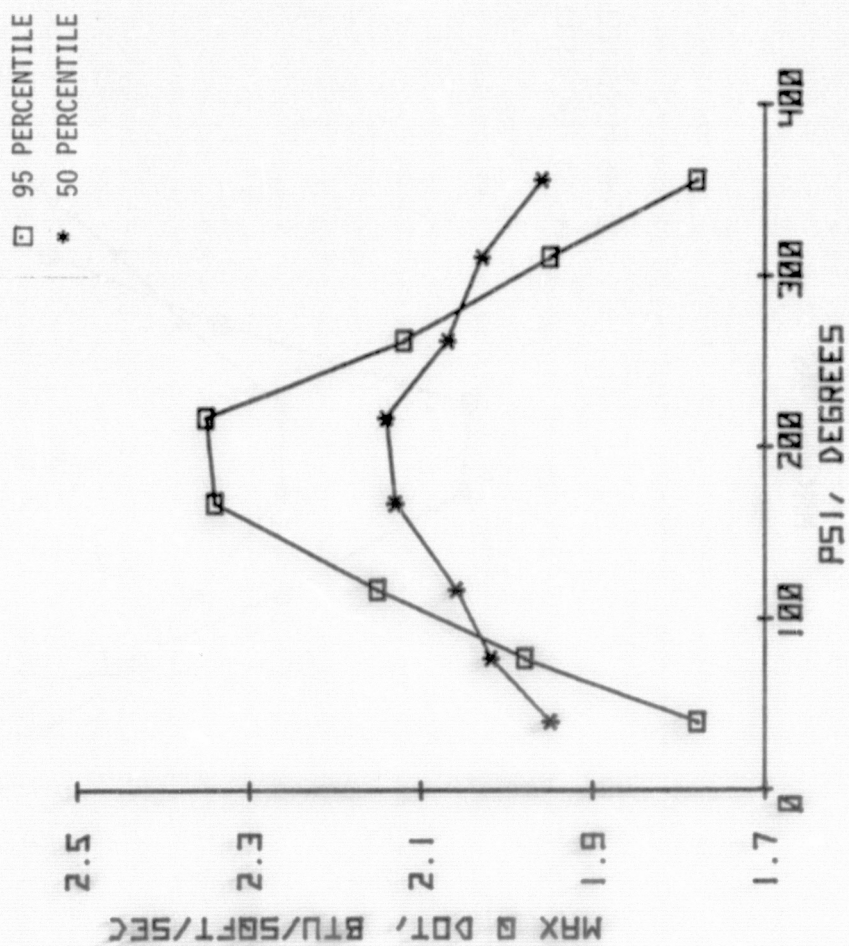


FIGURE A-57. - IMPACT OF WINDS/HEATING

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OFT-1 WIND CRITERIA	MAX FIRST STAGE HEAT RATE, q BTU/FT ² /SEC	FIRST STAGE HEAT LOAD, q_s BTU/FT ²
APRIL MEAN	1.95	71.3
95 PERCENTILE WIND EFFECTS	± 0.37	± 12
50 PERCENTILE WIND EFFECTS	± 0.19	± 5

FIGURE A-58. - IMPACT OF WIND CRITERIA/SRB STAGING

ENGINEERING ANALYSIS DIVISION/EX

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DATE _____

BY L. AUSTIN

PLOT NO. _____

OFT-1 WIND CRITERIA	Q, LB/FT ²	V _R , FPS	γ _R , DEG	h, FT.	α, DEG.	β, DEG.
APRIL MEAN WIND	23	3978	39.3	155521	1.9	0.1
95 PERCENTILE	±8	±60	±2.6	±3700	±.65	±2.6
50 PERCENTILE	±4	±25	±1.1	±2000	±.40	±.90

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FIGURE B-1. - NOMINAL TRAJECTORY COMPARISON

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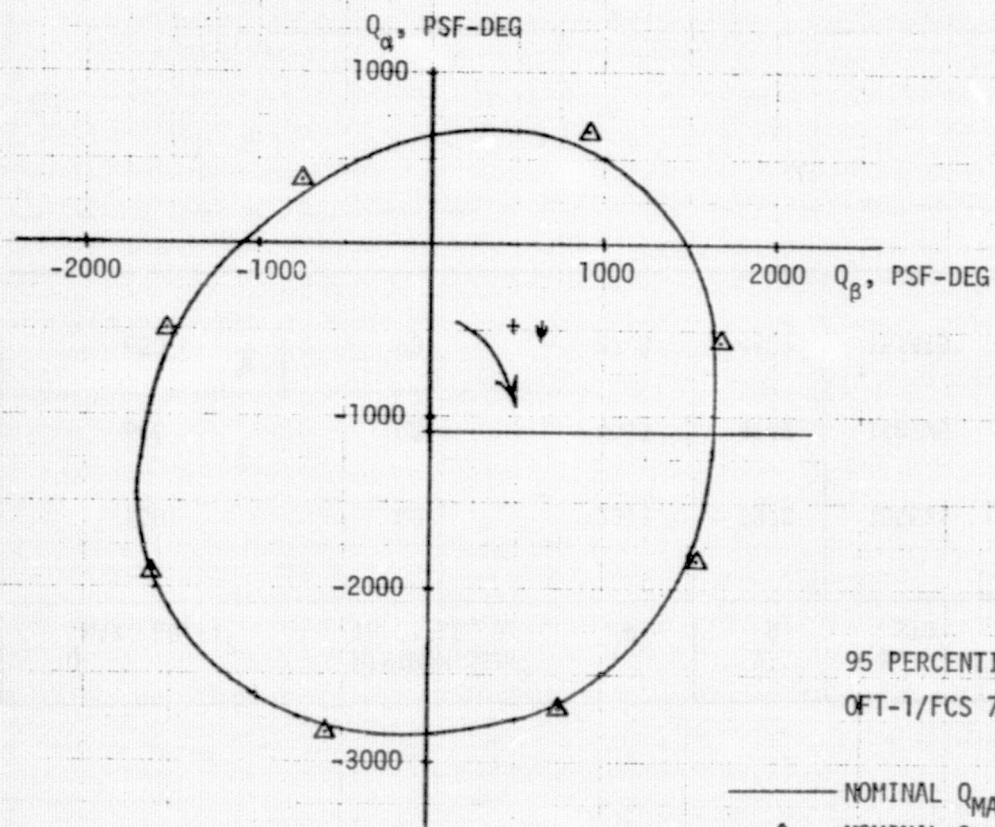
MISSION	Q_{MAX} , LB/FT ²	MINIMUM SSME THROTTLE, %	γ_R	V_R	h_{STG}	$Q_{STG,2}$ LB/FT ²	$\dot{q}_{MAX}$, BTU/FT ² /SEC
OFT-1	550	63	39.3	3978	155521	23	1.95
OFT-1	600	82	40.5	4147	158775	22	2.72
3A	650	93	27.8	4622	151415	38	3.35

FIGURE B-2.- OFT-1 SQUATCHELOID / M = 1.05

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95 PERCENTILE WINDS
OFT-1/FCS 7 RESPONSE

— NOMINAL $Q_{MAX} = 550$

△ NOMINAL $Q_{MAX} = 600$

FIGURE B-3

OFT-1 550 VS 600 NOMINAL Q_{MAX}

GUST AT M=1.05

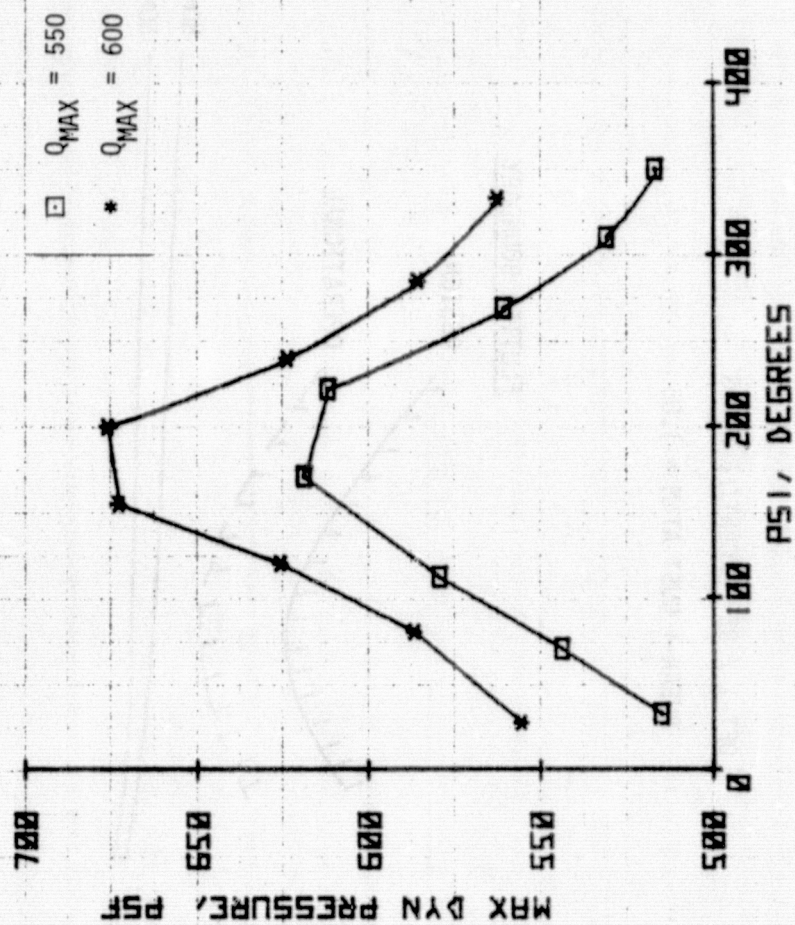


FIGURE B-4.- FLUTTER MARGIN / WORST CASE VECTOR WINDS

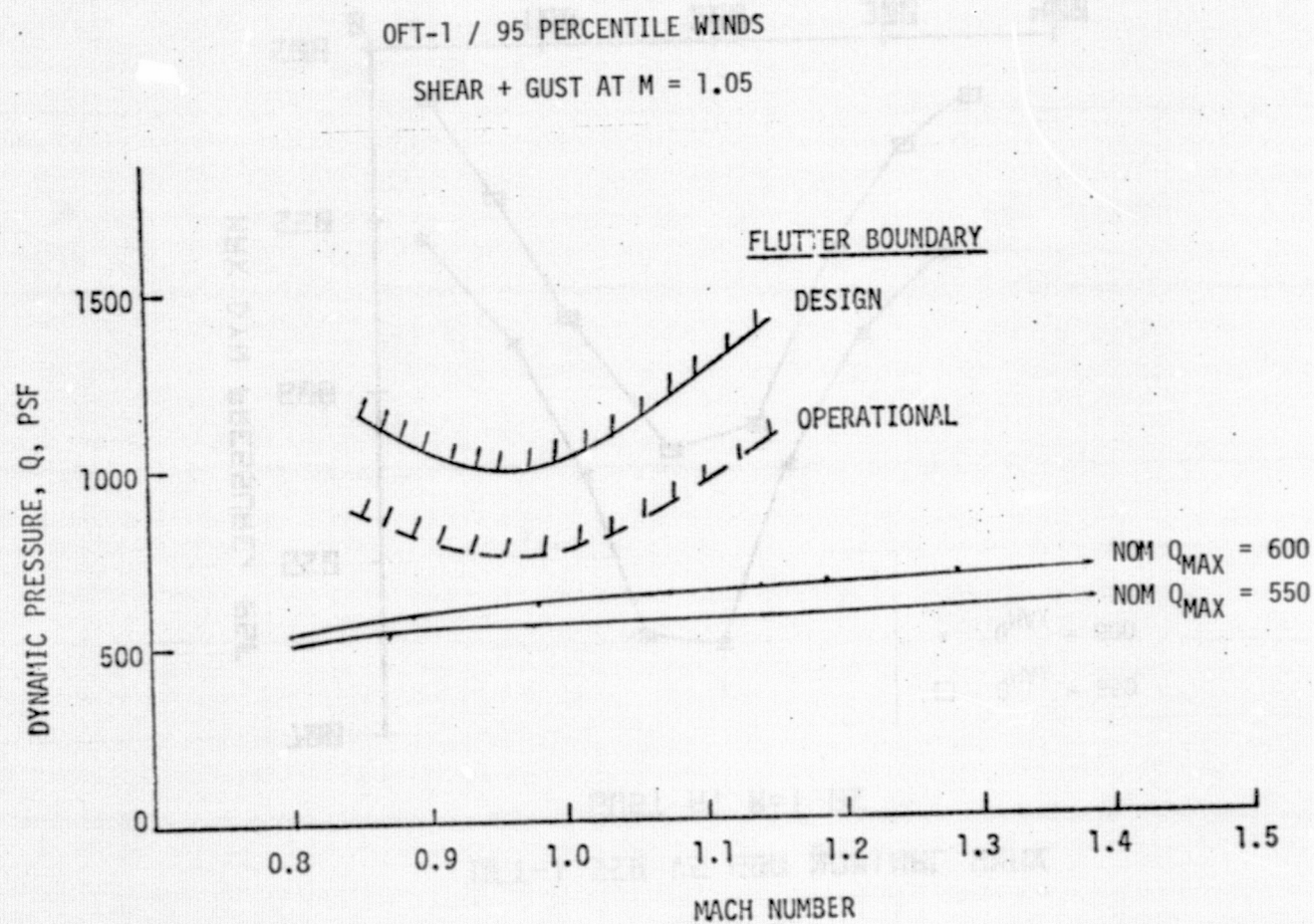
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FIGURE B-5

DEF-1 550 VS 600 NOMINAL QMAX

GUST AT $M=1.05$

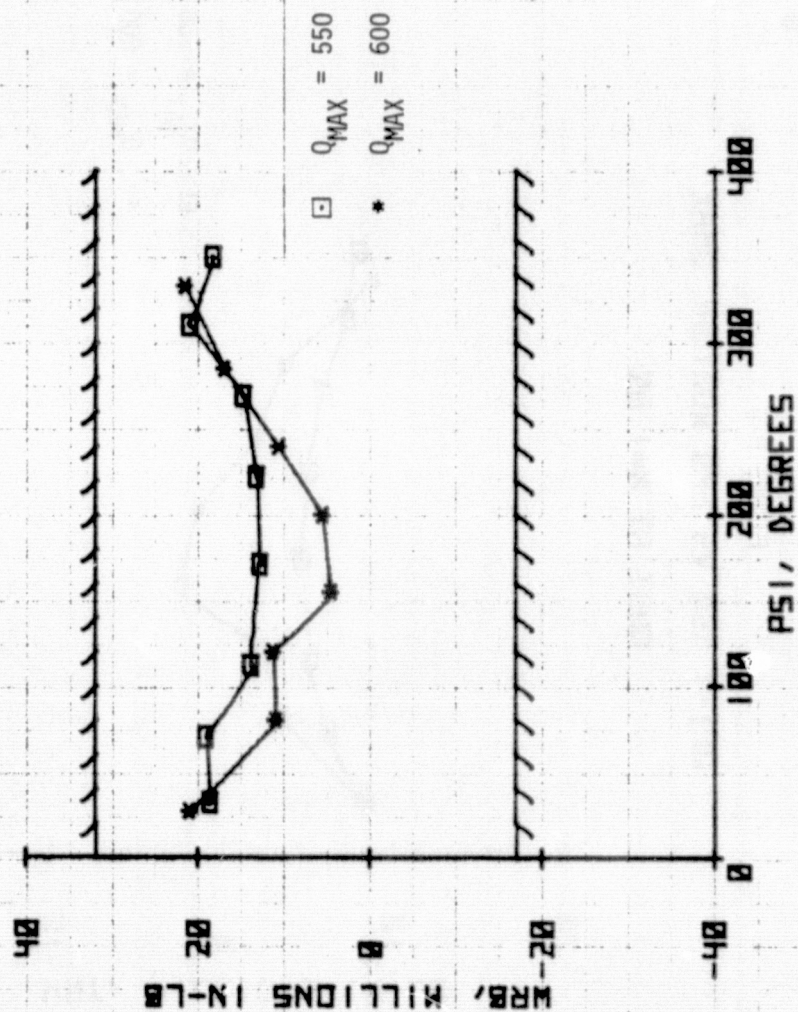


FIGURE B-6
 DFT-1 550 VS 600 NOMINAL QMAX
 GUST AT $M=1.05$

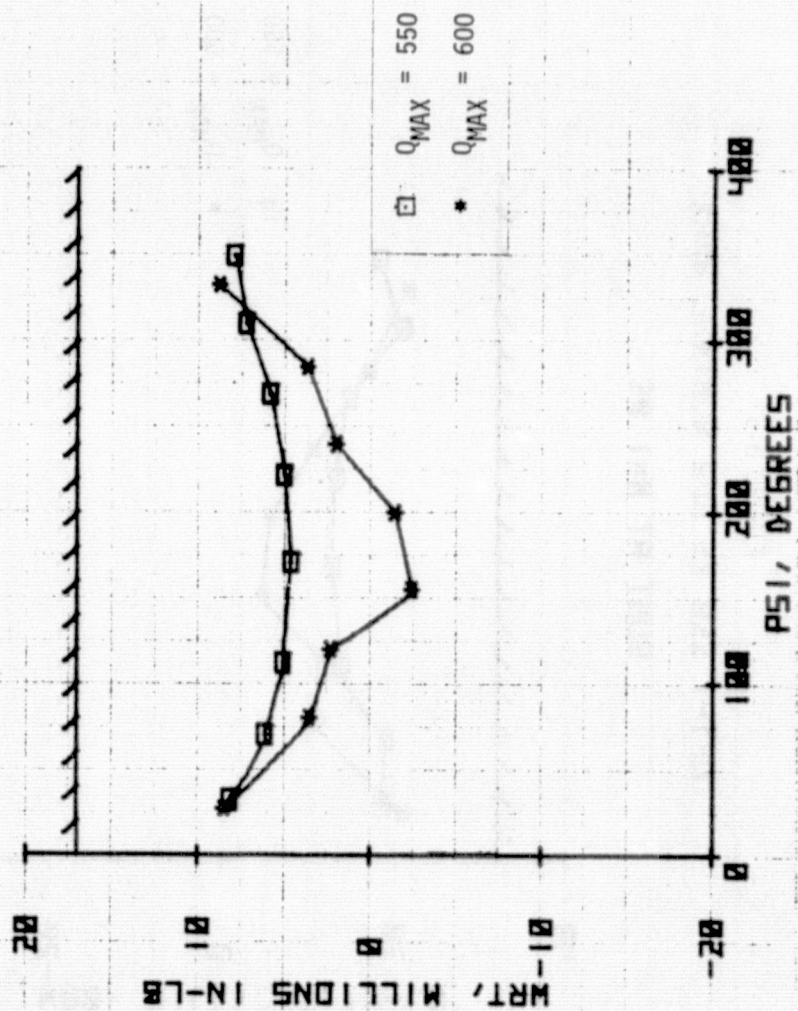


FIGURE B-7
 DFT-1 550 VS 600 NOMINAL Q_{MAX}
 GUST AT M=1.05

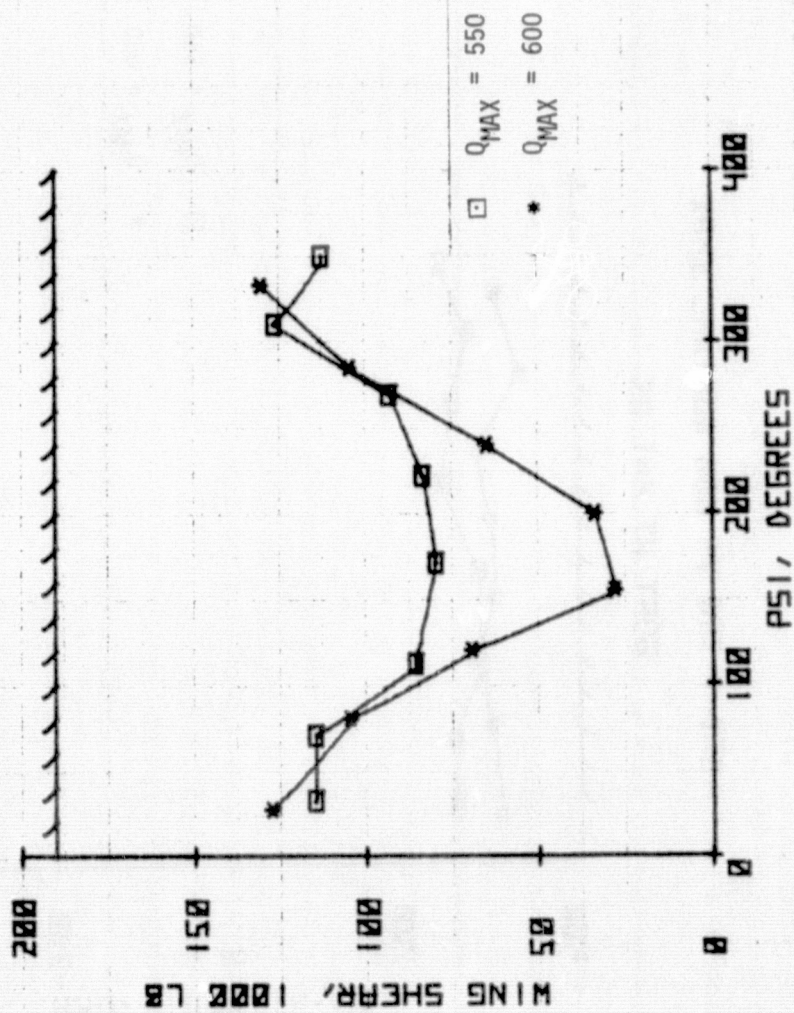


FIGURE B-8
 DFT-1 550 VS 600 NOMINAL QMAX
 GUST AT $M=1.05$

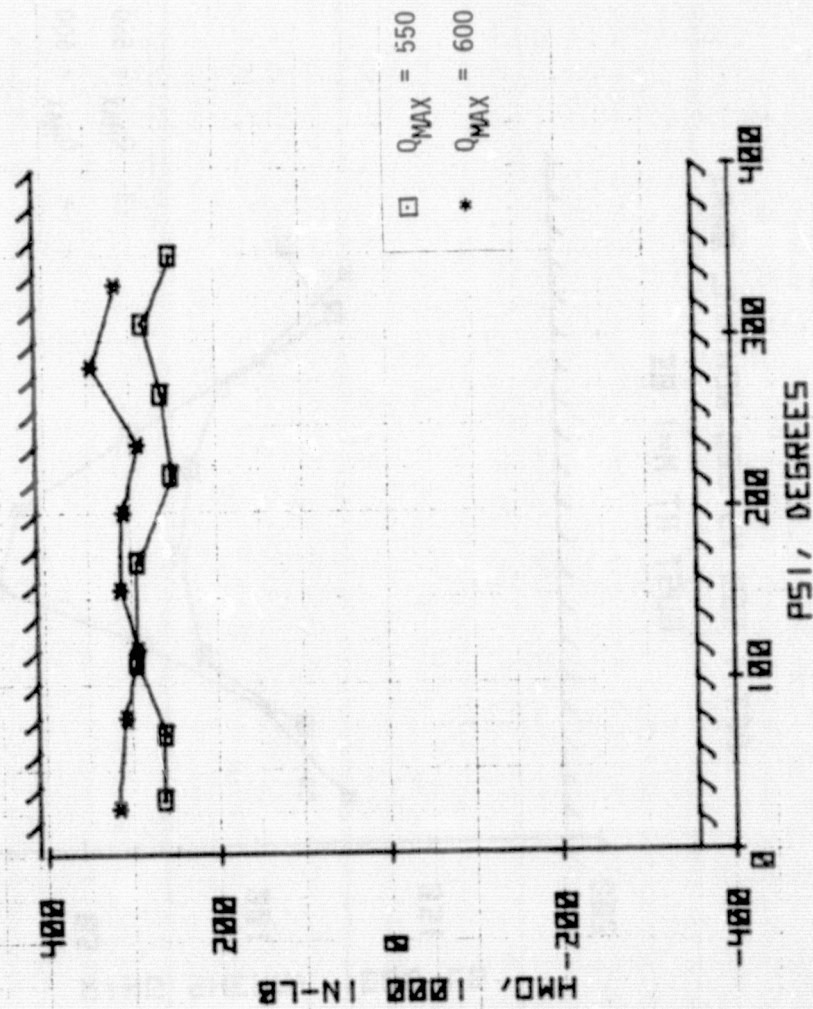


FIGURE B-9
 OBT-1 550 VS 600 NOMINAL Q_{MAX}
 GUST AT M=1.05

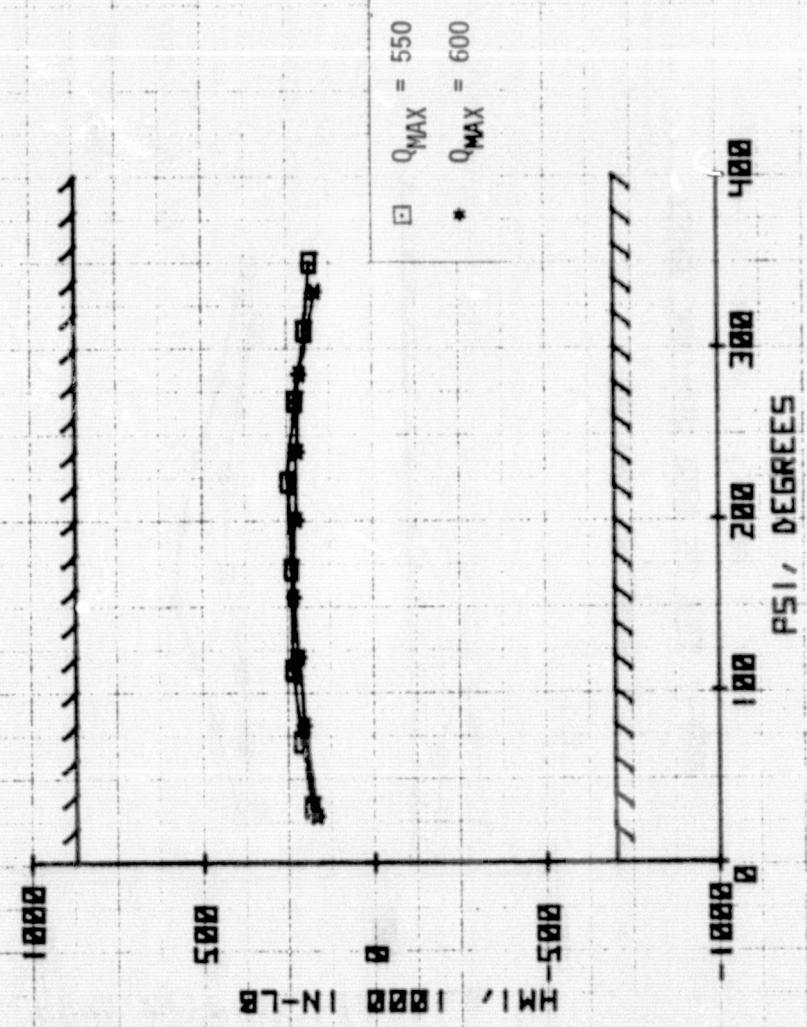


FIGURE B-10
OFT-1 550 VS 600 NOMINAL QMAX
GUST AT $M=1.05$

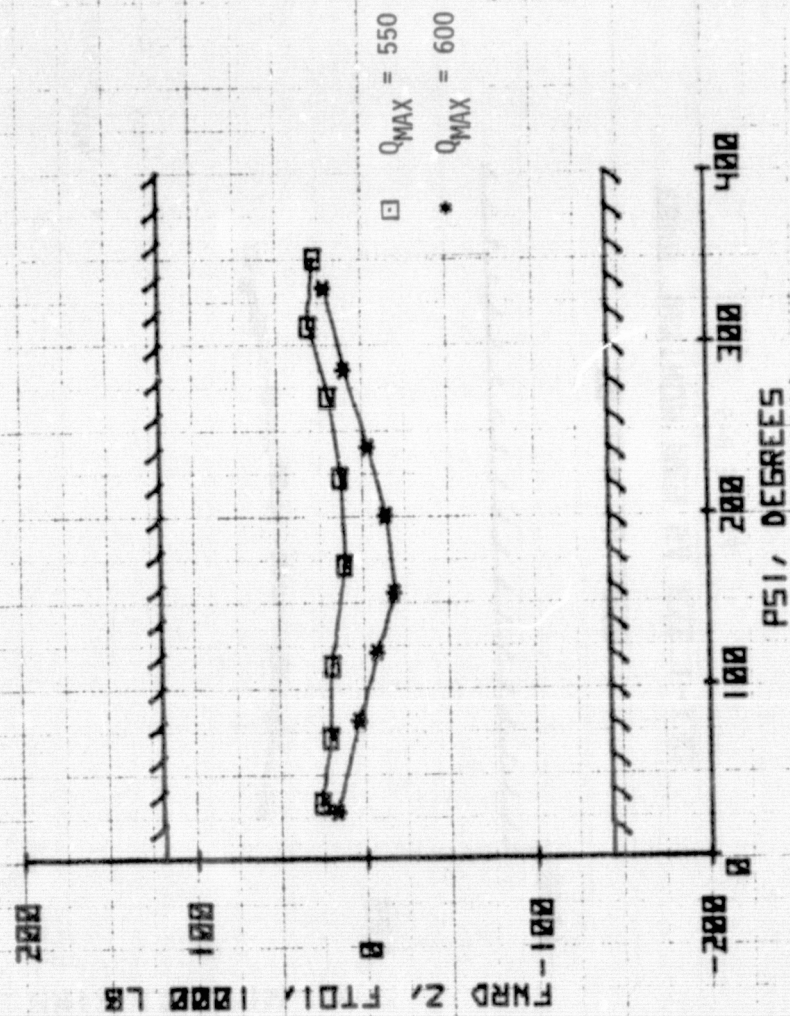


FIGURE B-11

QFT-1 550 VS 600 NOMINAL QMAX

GUST AT $M=1.05$

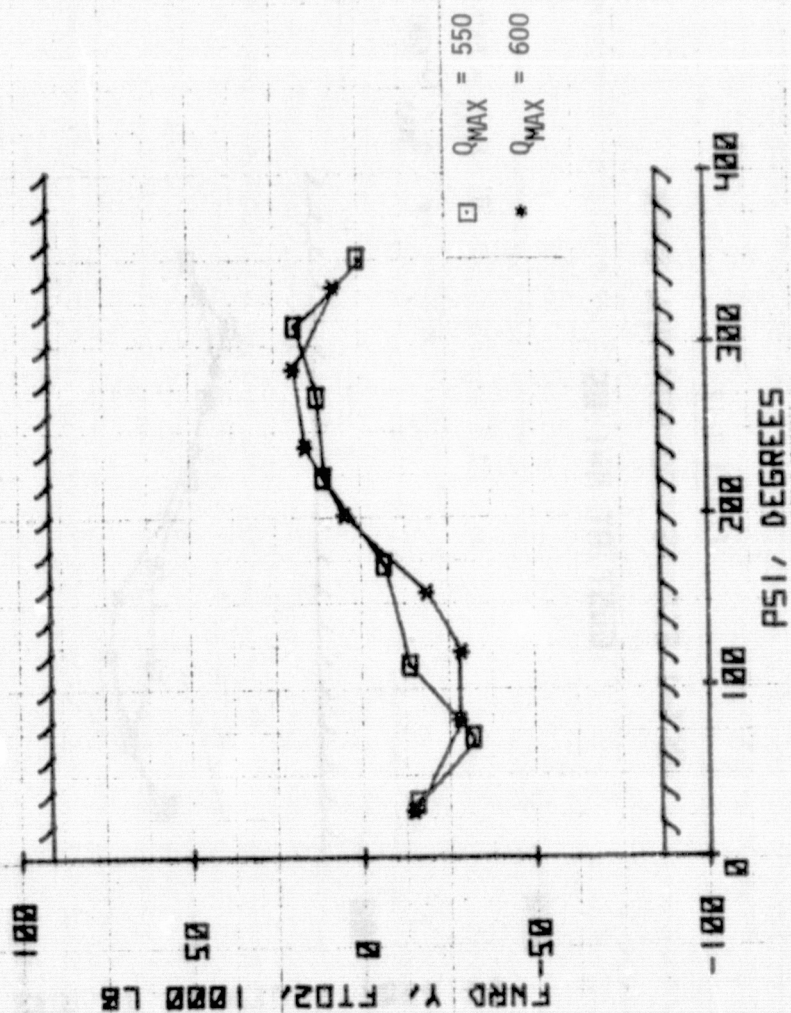


FIGURE B-12

OFT-1 550 VS 600 NOMINAL QMAX

GUST AT H=1.05

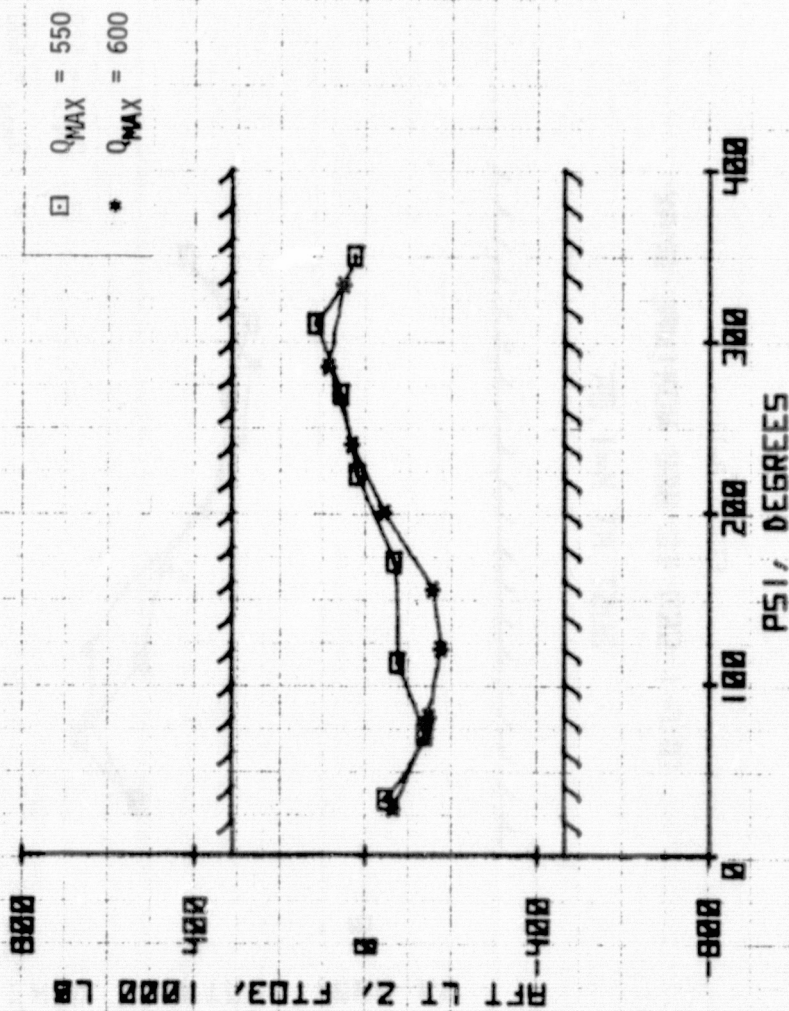


FIGURE B-13

OFT-1 550 VS 600 NOMINAL Q_{MAX}

GUST AT M=1.05

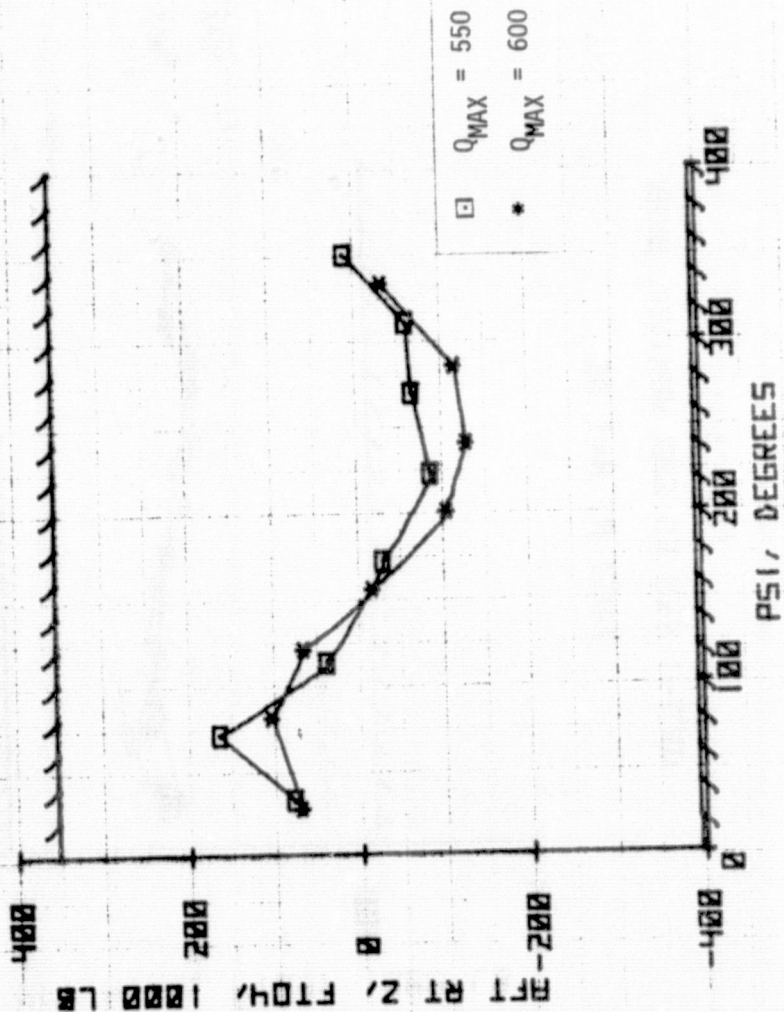


FIGURE B-14
 DFT-1 550 VS 600 NOMINAL QMAX
 GUST AT $M=1.05$

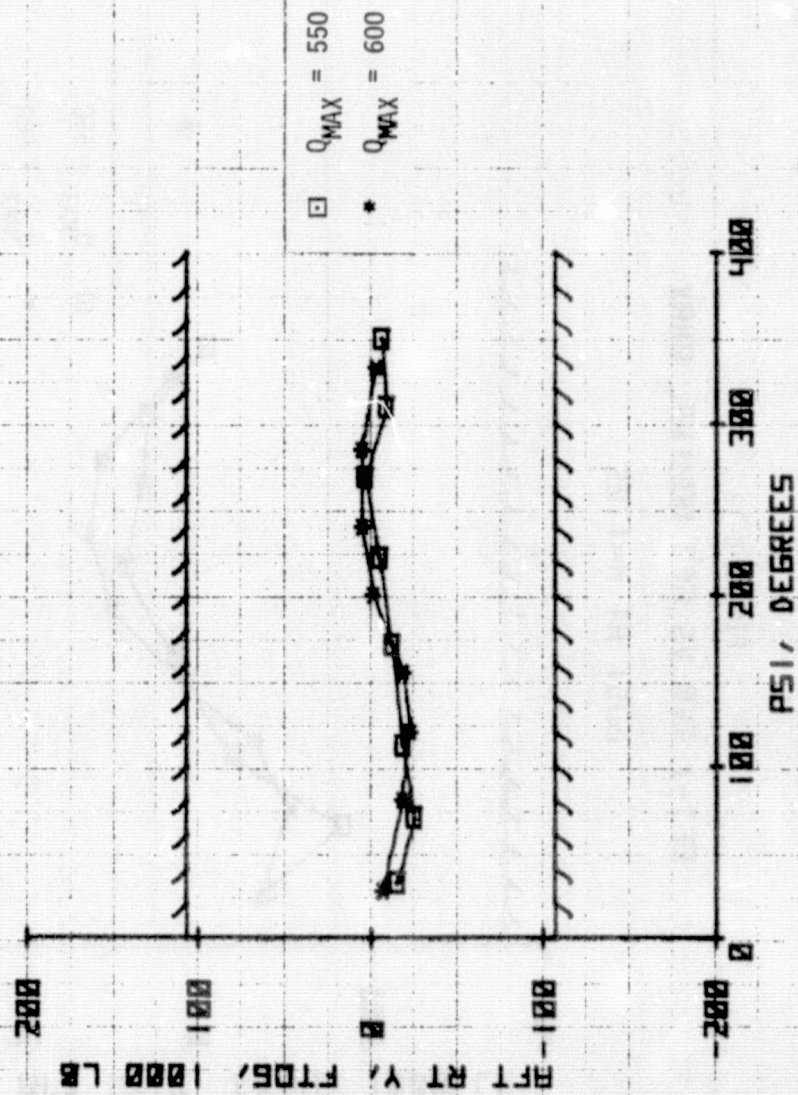


FIGURE B-15
 QFT-1 550 VS 600 NOMINAL QMAX
 GUST AT $M=1.05$

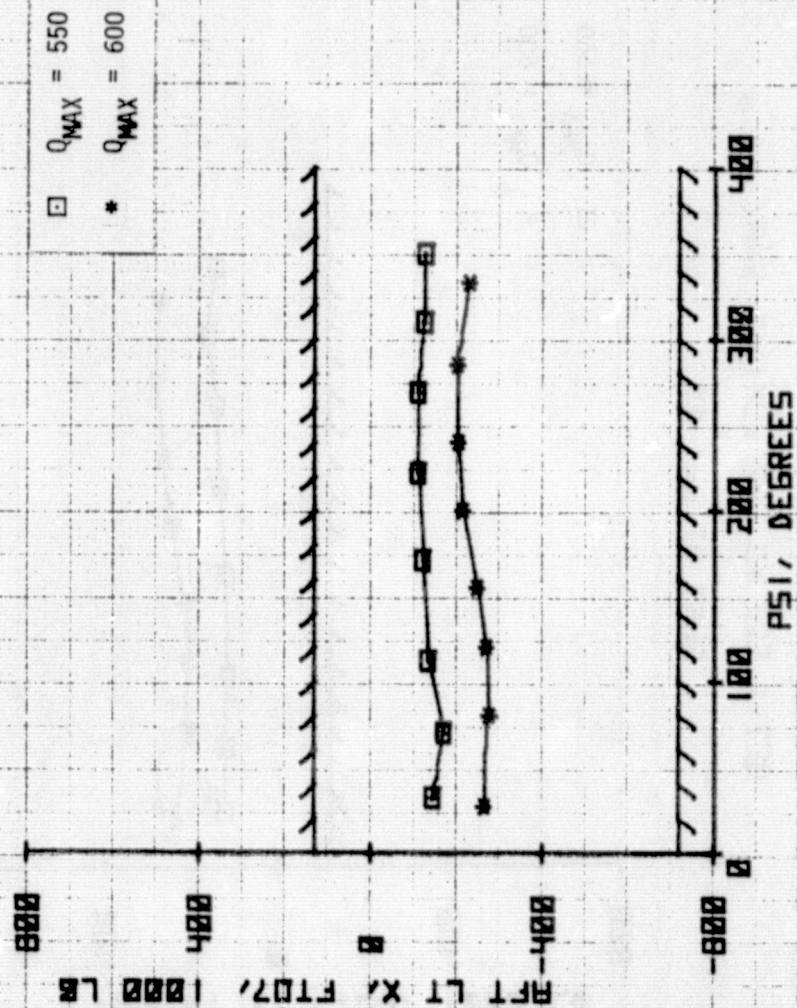


FIGURE B-16

OFT-1 550 VS 600 NOMINAL Q_{MAX}

GUST AT M=1.05

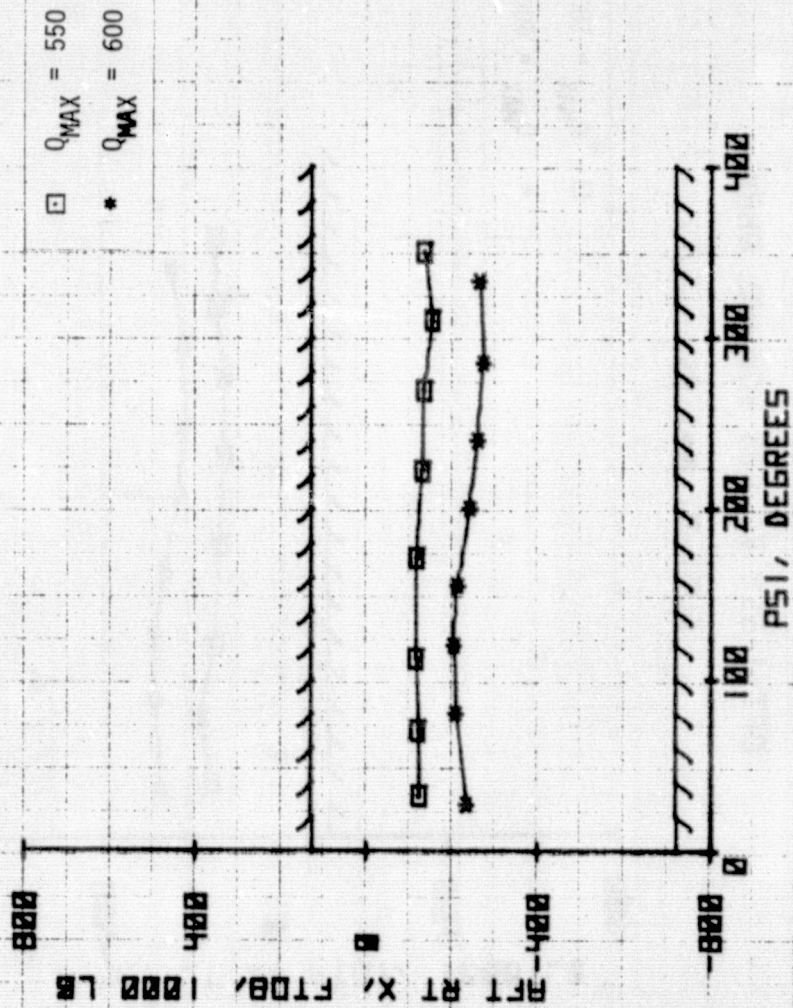


FIGURE B-17

OFT-1 550 VS 600 NOMINAL QMAX

GUST AT $M=1.05$

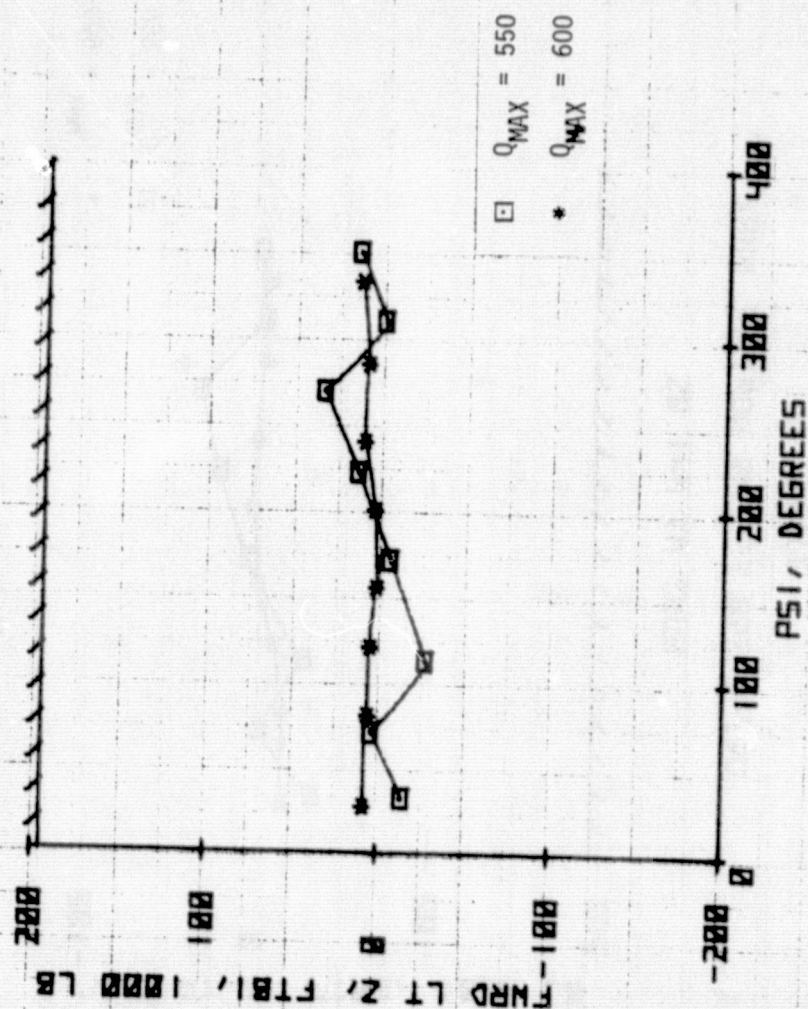


FIGURE B-18

OFT-1 550 VS 600 NOMINAL Q_{MAX}

GUST AT M=1.05

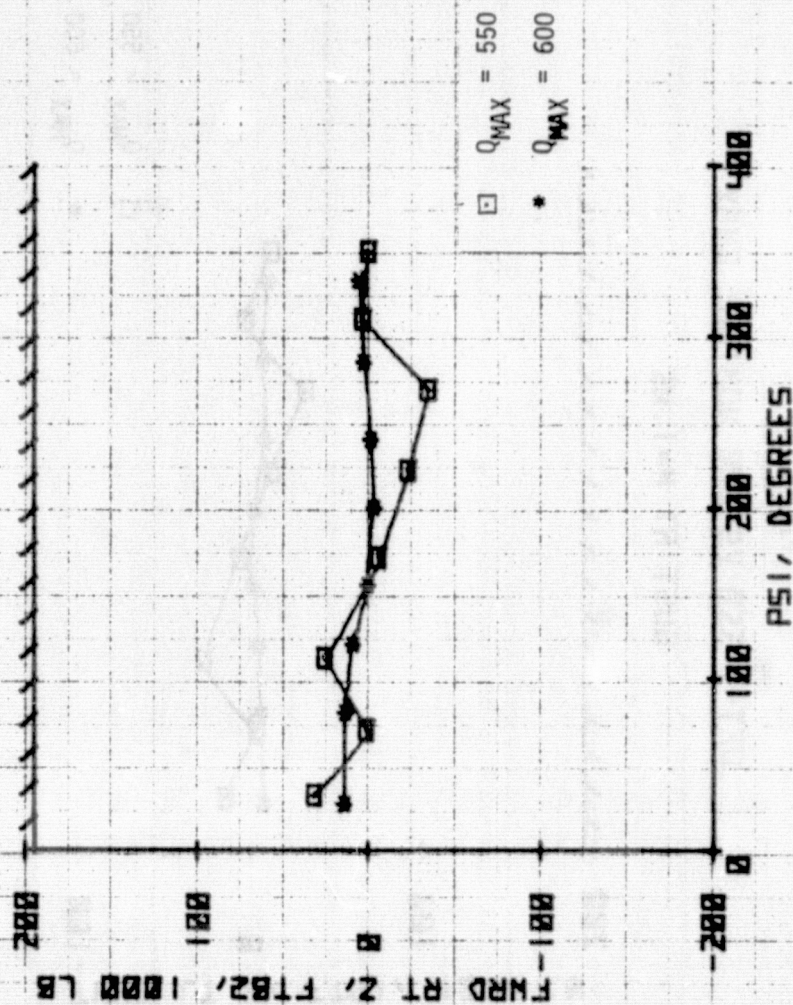


FIGURE B-19
 DFT-1 550 VS 600 NOMINAL Q_{MAX}
 GUST AT M=1.05

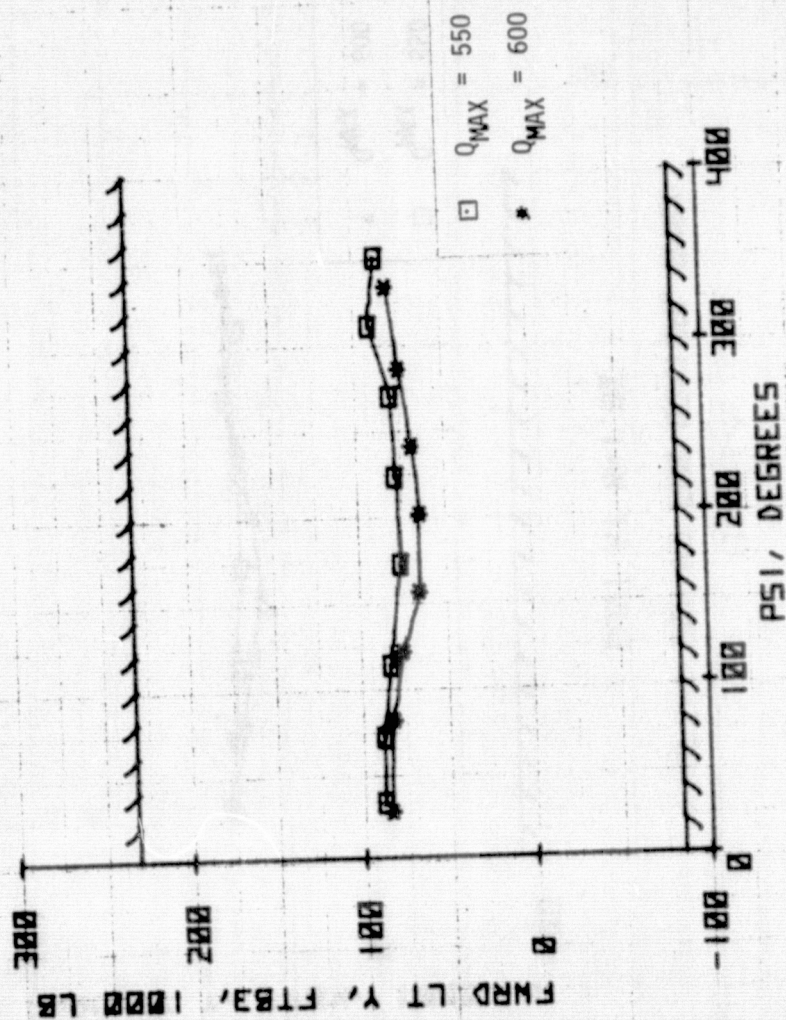


FIGURE B-20
 QFT-1 550 VS 600 NOMINAL QMAX
 GUST AT $H=1.05$

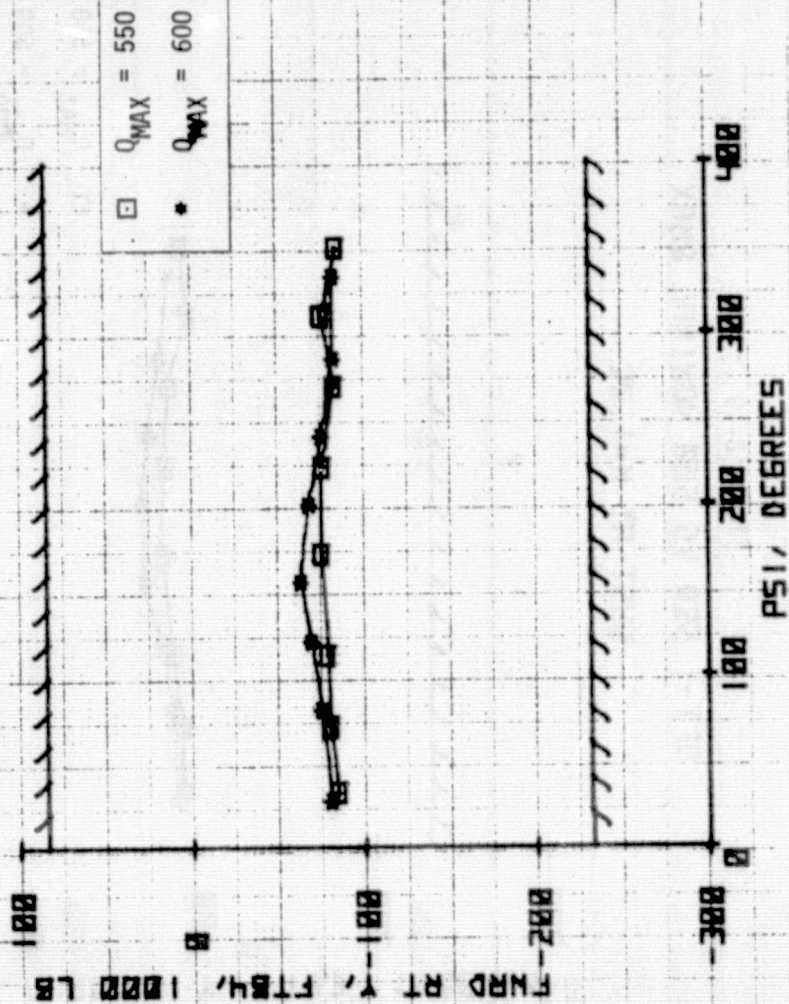


FIGURE B-21

OFT-1 550 VS 600 NOMINAL Q_{MAX}

GUST AT M=1.05

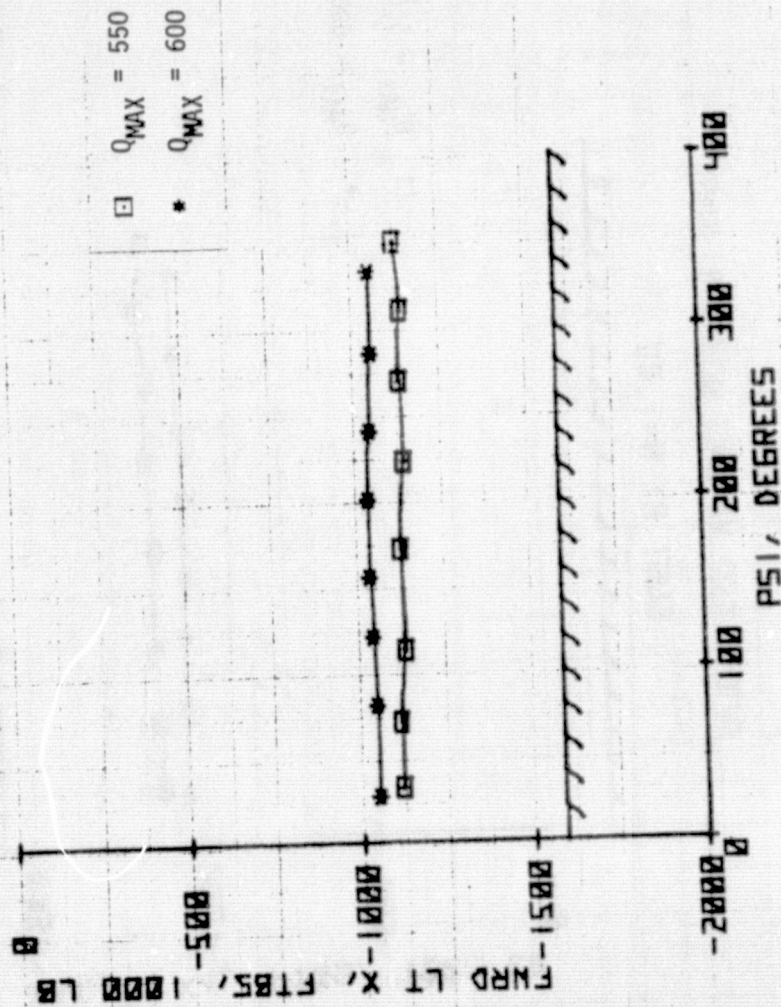


FIGURE B-23
 OFT-1 550 VS 600 NOMINAL Q_{MAX}
 GUST AT M=1.05

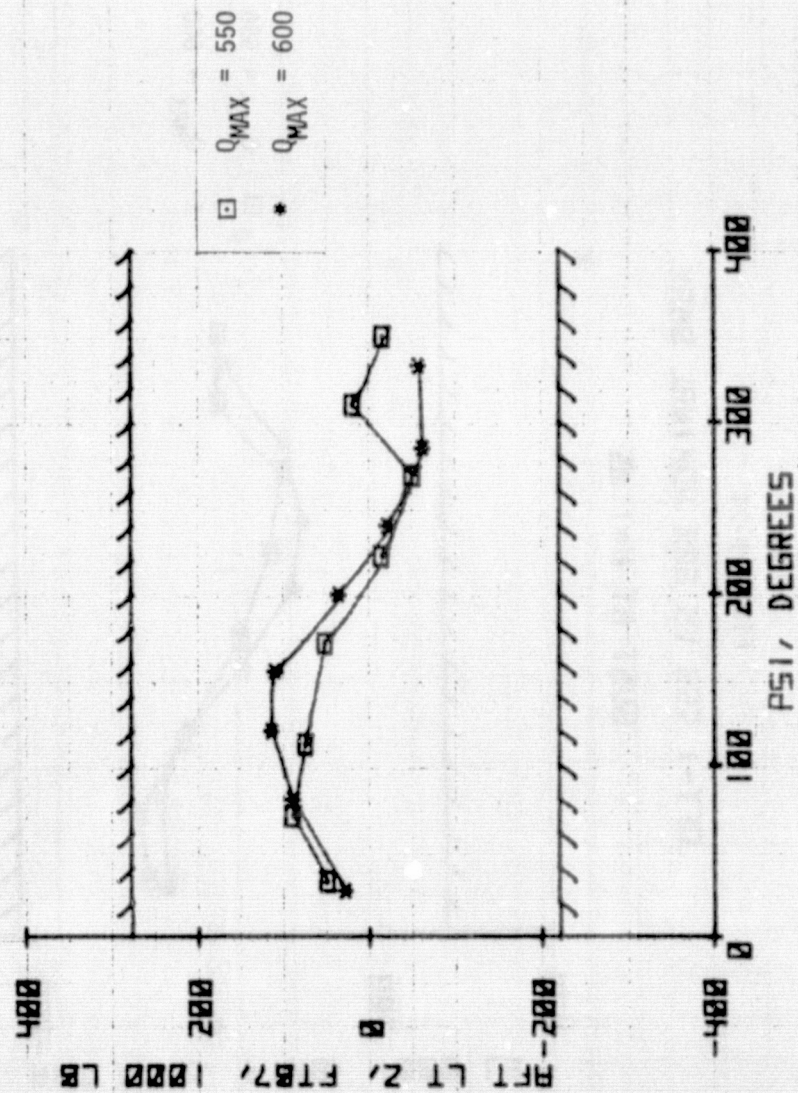


FIGURE B-24

OFT-1 550 VS 600 NOMINAL QMAX

GUST AT $M=1.05$

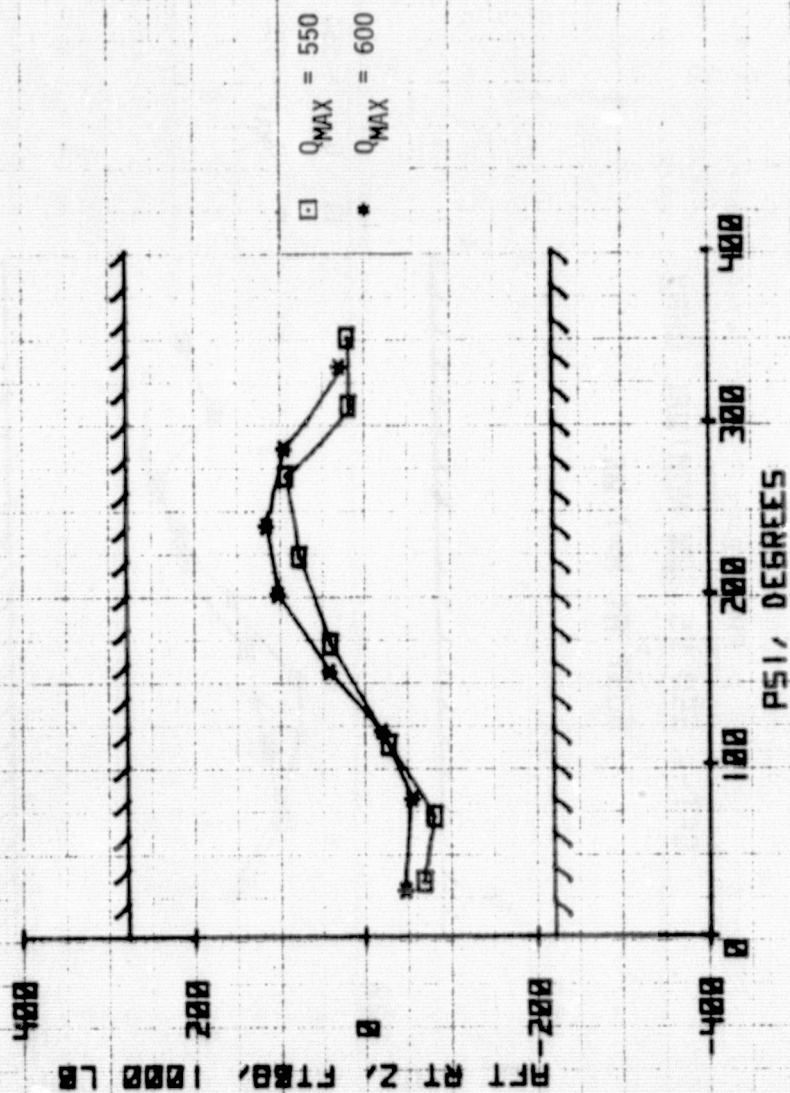


FIGURE B-25

OFT-1 550 VS 600 NOMINAL QMAX

GUST AT $M=1.05$

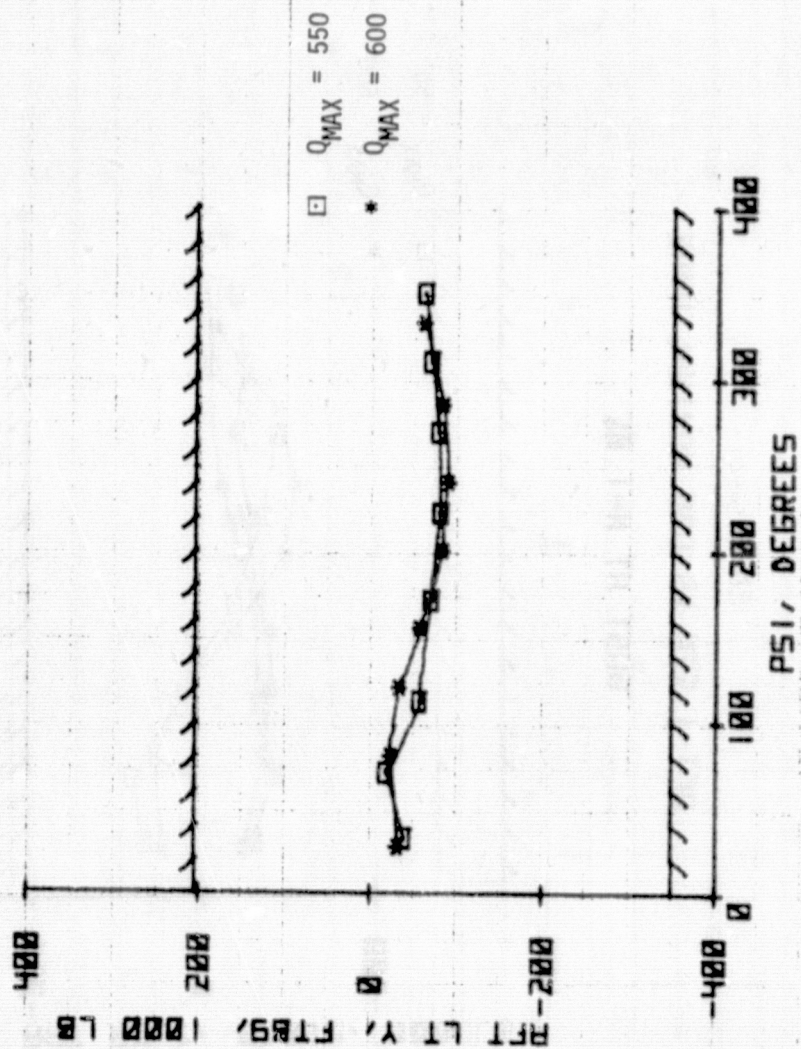


FIGURE B-26

OFT-1 550 VS 600 NOMINAL QMAX

GUST AT $M=1.05$

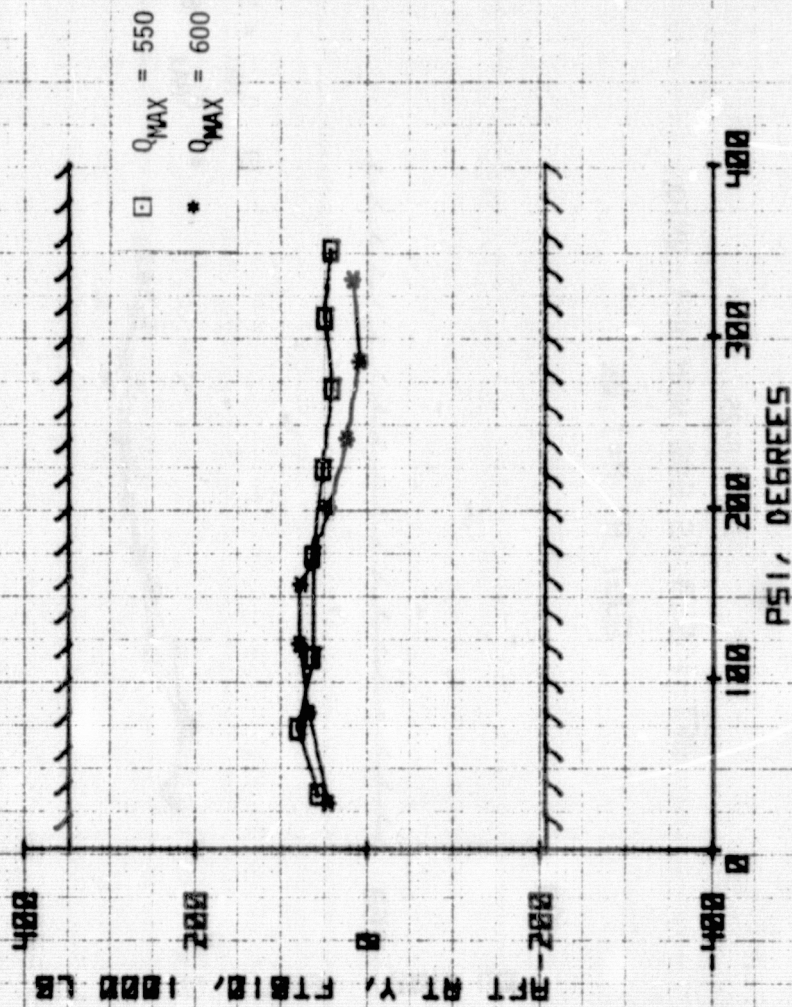


FIGURE B-27

OFT-1 550 VS 600 NOMINAL QMAX
GUST AT $M=1.05$

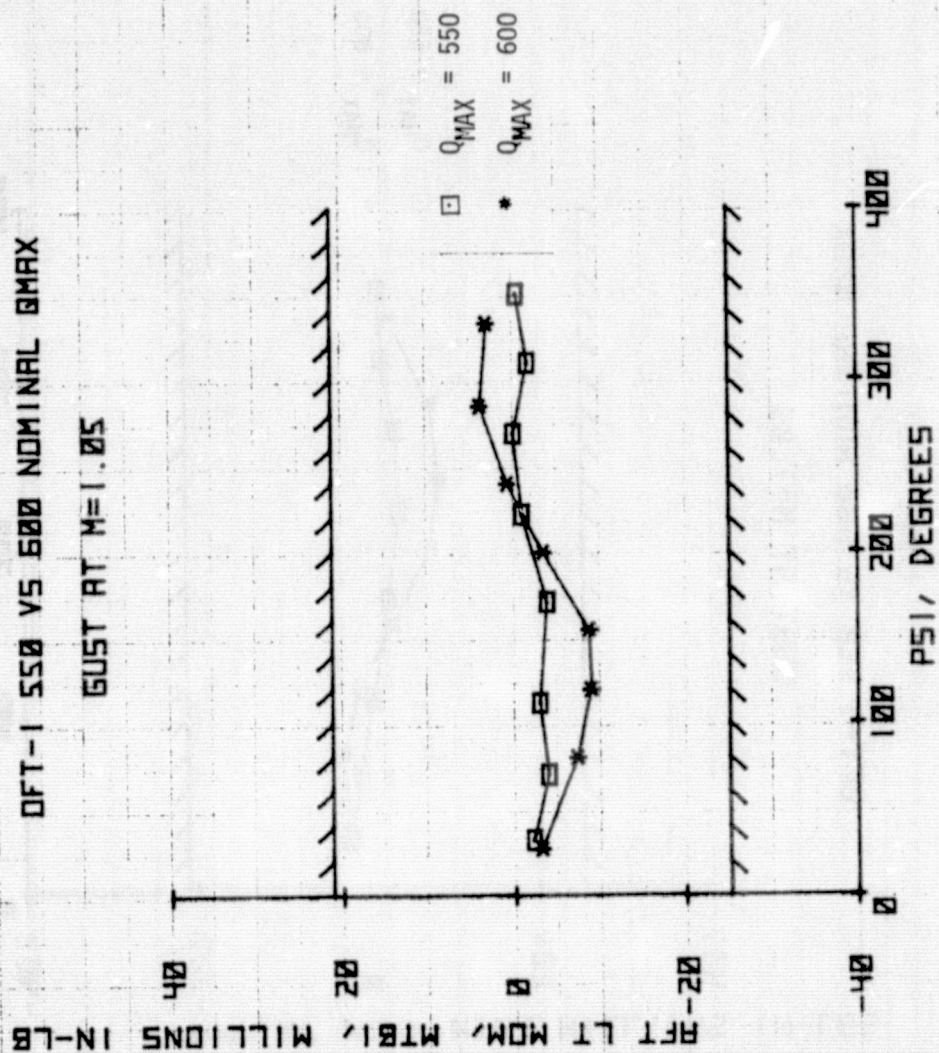


FIGURE B-28

OFT-1 550 VS 600 NOMINAL BMAX
GUST AT $M=1.05$

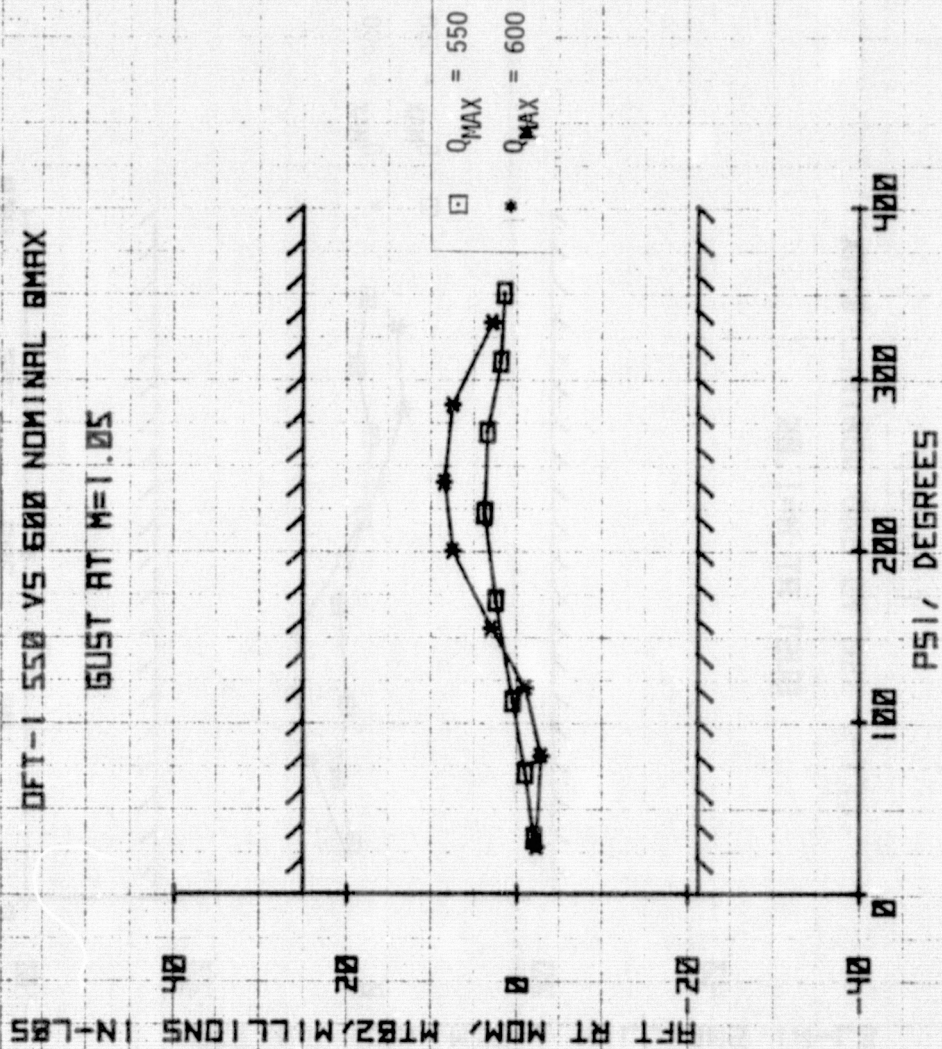


FIGURE B-29. - IMPACT OF 95 PERCENTILE WINDS

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE _____

BY L. Austin

PLOT NO. _____

LOAD INDICATOR	PERCENT MARGIN	
	$Q_{MAX} = 550$	$Q_{MAX} = 600$
WRB	45	41
WS	36	19
HMO	29	15
HMI	79	79
FT01	66	69
FT02	58	57
FT03	54	54
FT04	49	67
FT06	67	67
FT07	54	89
FT08	54	89
FTB1, 2	84	93
FTB3, 4	89	94
FTB5, 6	55	67
FTB7, 8	56	68
FTB9, 10	79	77
MTB1, 2	80	69
Note: Mach No. = 1.05		

FIGURE B-30. - IMPACT OF 95 PERCENTILE WINDS/HEATING

ENGINEERING ANALYSIS DIVISION/EX

BRANCH EX42

DATE _____

BY L. Austin

PLOT NO. _____

OFT-1 NOMINAL Q_{MAX} MAXIMUM FIRST STAGE
HEAT RATE, $\dot{q}$
BTU/FT²/SECFIRST STAGE
HEAT LOAD, q_s
BTU/FT²

550

1.95

71.3

WIND EFFECTS

 ± 0.35 ± 12

600

2.72

78

WIND EFFECTS

 ± 0.35 ± 12

FIGURE B-31.- IMPACT OF 95 PERCENTILE WINDS

ENGINEERING ANALYSIS DIVISION/EX

BRANCH FX42 DATE _____

BY L. Austin PLOT NO. _____

OFT-1 NOMINAL Q_{MAX}	Q_{STG} , LB/FT ²	V_R , FT/SEC	γ_R , DEG	h , FT	α , DEG	β , DEG
550 WIND EFFECTS	23 ±8	3978 ±60	39.3 ±2.6	155,521 ±3,700	1.9 ±.65	0.1 ±2.6
600 WIND EFFECTS	22 ±8	4147 ±60	40.5 ±2.6	158,775 ±3,700	2.0 ±.65	0.1 ±2.6

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